**Front Cover**  magnesium carbonate, synthesized by hot isostatic pressing at T=600°C, P=300 MPa (grain size = 1.1 μm, SEM image by J. Newman, from Masters thesis research of N. Davis, 2005)

**Back Cover**  high-resolution seismic image of collapsed paleokarst system (from 3-D reflection survey, Y. Sun)
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Chapter 1 - Introduction

1.1 Welcome from the Department Head

The Department of Geology and Geophysics welcomes you to Texas A&M University (TAMU). We are grateful to you for agreeing to serve as external reviewers of our academic program. Our last external review was completed in 2002, and it is TAMU policy to conduct an academic review once every eight years. This year's review offers a greater challenge than did our last, as we seek an evaluation of all of our educational programs, graduate and undergraduate, while the 2002 review was restricted to our Ph.D. program. We look forward to the opportunity for a comprehensive evaluation of our department. We continue to target our Ph.D. program for growth and improvement, as we seek to address fundamental questions about the Earth. However, we also acknowledge our responsibilities to the state and nation, because as a large department at a land-grant university, we are called to educate geologists and geophysics able to solve scientific problems, to become educators at all levels, and to tackle problems of energy, environment, and climate.

Some know Texas A&M University as the home of the fightin' Texas Aggies. However, our goal in this self-study report is to introduce you to our intellectual home, the Department of Geology and Geophysics, within its unique setting, the College of Geosciences, its affiliated departments, and research centers. We prepared this report specifically for your review. We seek your evaluation of our current educational and research programs, and we seek your perspectives and advice as we plan to build and improve our educational and research programs. We include a brief history of Texas A&M and the Geology and Geophysics Department. This is followed by a comparison of the department, with its current faculty, students, and staff, to the department at the time of our last review. We offer information on the Department's organization and finance, as well as affiliations with other departments and centers. Academic curricula and student demographics are reviewed separately for undergraduate and graduate degree programs, as are program assessments and outcomes. Areas of research strength are identified, research facilities are described, and we conclude with an internal assessment and initiatives we plan to pursue. We provide, under separate cover, extensive appendices that provide curricula vitae for the faculty, details of the undergraduate and graduate curricula and their assessment, research publications, grants and contracts, service to the scientific community, and the strategic plan that emerged from our last external review.

We look forward to receiving your evaluation and recommendations as we prepare to develop a new strategic plan to build and improve our department's academic program. We understand that the request we make of you requires significant time and effort. Let me assure you of the
importance of your review and that your contribution is greatly appreciated. Please feel free to contact me if you have any questions or need information that is not contained in this report.

Andreas Kronenberg
Professor and Department Head
1.2 Charge to Review Committee

Prepared July 1, 2009

This letter provides you with background on the Department of Geology and Geophysics at Texas A&M University, and explains the expectations for our upcoming external review. Geology and Geophysics has been recognized as a separate department at Texas A&M since 1922. The Department received approval to offer a B.S. in Geology in 1930, a B.S. in Geophysics in 1957, a B.A. in Geology in 1998, a M.S. in Geology in 1951, a M.S. in Geophysics in 1959 and Ph.D. degrees in Geology and in Geophysics in 1959. Approximately 100 undergraduate students are typically enrolled in Geology or Geophysics degrees, with recent increases up to 180, and approximately 100 graduate students are enrolled in graduate degree programs in Geology or Geophysics.

This activity is part of a periodic review of all Texas A&M University academic programs, and offers an opportunity to assess the standards of the programs and to learn from review team members’ experiences with similar programs.

I request that the review team examine the undergraduate, graduate, and research programs of the Department of Geology and Geophysics using the materials that will be provided, information you gain through personal interactions while visiting Texas A&M, and any additional information that you might request. While evaluating the program, please consider the allocation of resources within the department (both human and fiscal) and the absolute level of support the Department receives from the University. Please comment as appropriate on current and potential leveraging of these resources, as well as the current and potential interaction with other departments and groups, both on campus and off.

Also, please address the issue of learning-based outcomes:

- Does the department have ongoing and integrated planning and evaluation processes that assess its programs and services, result in continuing improvement, and demonstrate that the department is effectively accomplishing its mission?
- Has the department identified expected outcomes for its educational programs?
- Does the department have evidence of improvement based upon analysis of results?

In addition, I ask that you address the impact of the Faculty Reinvestment Program, started by Texas A&M University in 2003. The reinvestment program has resulted in the hiring of almost 500 new faculty members dispersed throughout the University. The goal is to improve the quality of education for Texas A&M students by having more faculty available for mentoring and advising, whether by offering more courses and sections, or simply by being more responsive to student needs. Through this review we plan to track and measure real increases and improvements in the quality of the graduate and undergraduate experiences across all
dimensions. We ask that you assess the success of the department in moving its teaching and research agendas forward with these hires. The reinvestment program enabled the department to hire four bright young geoscientists in such diverse fields as sediment transport modeling, dynamic earthquake rupture, and geobiology applied to the metabolisms of earliest life on Earth.

I look forward to meeting with you and the entire committee in January, 2010. If you have any questions or require additional information, please contact me.
1.3 Departmental Strengths and Challenges

As you initiate your review, please know that we wish to benefit from your insights, some of which may confirm our own self-evaluation, and some that we may not have recognized. We believe that the Department of Geology and Geophysics has balanced commitments to education and research. We are interested in knowing whether you believe that balance has been achieved, and whether we can achieve excellence by our approach. In this section, we outline our perceived strengths and challenges. Ultimately, we seek your independent evaluation and your impressions of our opportunities.

These are exciting times for our department, with the realization of new faculty hires in our department, our college and across the campus under Texas A&M's Reinvestment Program, and the university's Ocean Drilling and Sustainable Earth Science (ODASES) initiative. Over a time period in which faculty hiring has been limited at many institutions, we have interviewed and hired some of the finest Earth scientists available in new areas of research, in addition to replacing key faculty in our traditional areas of strength. We are proud of our new Reinvestment and ODASES faculty and their early accomplishments. However, the growth in our faculty numbers has been checked somewhat by faculty losses.

More than ever, we recognize new opportunities to solve problems related to energy, environment, and climate as concerns about peak global oil production, water resources, contaminants, and sustainability of modern life are heightened. We have recently hired two outstanding faculty members in sedimentology and stratigraphy and established a new, endowed Center for Petroleum and Sedimentary Systems, rebuilding our traditional strength in petroleum geosciences. We have excellent faculty and students engaged in environmental geosciences, and we are committed to building this program in context of the university's interdisciplinary water program and the college's emphasis on environmental geosciences. We have outstanding geoscientists examining the geologic history of climate change and biotic response, and we have established new geochemistry laboratories for stable and radiogenic isotope studies. Texas A&M has a long standing strength in tectonophysics and rock mechanics, and recent studies of deep crust and mantle processes have involved interdisplinary approaches in geochemistry, mineral physics, and geophysics. In addition to basic science questions of these fields, applications include reservoir rock properties, earthquake source mechanisms, and potential methods of CO₂ sequestration.

We are proud of our students, and we expect a great deal of them. Our undergraduate B.S. programs in geology and geophysics emphasize fundamental geological disciplines, rigorous math and science backgrounds, hands-on learning in field, laboratory and problem-solving courses, and undergraduate research opportunities. Our graduate M.S. and Ph.D. programs
emphasize independent research, underpinned by advanced coursework and faculty advising. Students in the Department benefit from significant numbers of scholarships and fellowships generated by industry contributions and alumni endowments. In addition, the Department supports many graduate students as teaching assistants, through our commitment to introductory geology courses that fulfill broadening requirements of non-science majors. Assessments of our programs reveal that placement of our undergraduate students in graduate programs is excellent, and many of our students, graduate and undergraduate, benefit from summer internships. Placement of graduate and undergraduate students in geoscience careers, both in the energy and environmental industries, is excellent.

The Department of Geology and Geophysics also faces a number of challenges. While many faculty members have an excellent record of publication, we are not satisfied by the publication record of our graduate students. For those students beginning industry careers, this is not a serious limitation; for students wishing to pursue careers as college or university faculty, this is a problem we must continue to address. We would like to improve our recruitment of Ph.D. students capable of, and interested in, careers as faculty and research scientists. With greater numbers of students who publish their research and entertain academic careers, we expect the intellectual experience of all students in our department will be elevated. In addition, increased participation by students in publication should contribute to research productivity of our faculty. We actively recruit graduate students at all levels, but we need to improve our ability to attract a larger number of excellent Ph.D. students.

The Department has a number of faculty members whose research is well funded. However, averaged over the entire department, we do not have the extramural funds we would like. Research funding is important, not only for the work itself, but to increase the number of graduate student research assistantships we are able to offer. We believe that increased availability of research funding would increase the number of Ph.D. students we attract to our department, and would give students, currently funded as teaching assistants, more time to dedicate to research and publication.

With the Department's reputation in petroleum geosciences, its connections with the energy industry, and public anticipation of increasing energy costs, the student numbers in our department have increased dramatically, particularly in our undergraduate programs. One of the expressed goals of Texas A&M's Reinvestment Program is to offer students greater access to faculty. Thus, our increasing student numbers challenge us to maintain our current class sizes. We have doubled the number of lecture sections and labs for key required courses to keep class sizes small and maintain our standards. Recent University standards require us to offer our students required writing-intensive courses, in which students rewrite papers in response to editorial marks of the instructor, and resubmit them for a second reading. More generally, we
believe that a number of our courses should be re-examined to address emerging issues of the 21st century (at the undergraduate and graduate levels), to address cutting-edge scientific questions, and to coordinate our courses better.

The new Berg-Hughes Center for Petroleum and Sedimentary Systems will increase our stature in applied, petroleum geosciences. In addition, we wish to build our environmental geosciences, program, our life, climate, and Earth history program, and to maintain strengths in geophysics and tectonophysics, much as we have done in geochemistry.
1.4 Schedule of Review

Travel/Welcome (Sunday, January 24, 2010)

2:00-5:00 p.m. Review team arrives in College Station, picked up at airport and escorted to Reveille Inn by Department Head, Andreas Kronenberg

6:30-8:30 p.m. Andreas Kronenberg hosts dinner at local restaurant

Day 1 (Monday, January 25, 2010)

7:30-8:30 a.m. Entry interview at the Reveille Inn with Interim Executive Vice President for Academics and Provost, Karan Watson, Vice Provost, Martyn Gunn, Interim Dean of Graduate Studies, Robert Webb, and Interim Associate Provost for Undergraduate Studies, Pamela Matthews

Breakfast served. Vice Provost and other administrators provide charge to reviewers and provide institutional perspective.

Review team transported to campus by Andreas Kronenberg

8:30-9:00 a.m. OPEN/Travel time, Review team transported to campus by Dept. Head

9:00-10:15 a.m. Meet with Dean of College of Geosciences, Kate Miller (202 O&M)

10:15-11:30 a.m. Meet with Department Head, Andreas Kronenberg (108 Halbouty)

11:30-11:45 a.m. OPEN/Travel Time

11:45am-1:15pm Lunch with Department Heads or their representatives, Kenneth Bowman (Atmospheric Sciences), Douglas Sherman (Geography), Piers Chapman (Oceanography), and Stephen Holditch (Petroleum Engineering) and with IODP Director Brad Clement (University Club)

1:15-1:30 p.m. OPEN/Travel Time

1:30-3:00 p.m. Tour departmental facilities, Andreas Kronenberg and others

3:00-4:20 p.m. Meet with Faculty (327 Halbouty)

4:20-4:30 p.m. OPEN

4:30-5:10 p.m. Meet with Senior Faculty (Professors, 327 Halbouty)

5:10 -5:30 Travel Time

5:30 -7:00 Reception with Faculty at Kronenberg residence

7:00-7:30 OPEN/Travel Time

7:30 p.m. Dinner and work session for review team, escorted to Reveille Inn by Kronenberg
Day 2 (Tuesday, January 26, 2010)

7:00-8:00 a.m.    Reviewers eat breakfast on their own at hotel, escorted to Halbouty Bldg by Bruce Herbert

8:00-8:30 a.m.    OPEN/Travel Time

8:30-11:40 a.m.   Meet with Faculty Groups (327 Halbouty)
                 8:30 a.m. - Petroleum Geosciences
                 9:15 a.m. - Water Resources & Environmental Geosciences

10:00-10:10 a.m.  OPEN
                 10:10 a.m. - Life, Climate, and Earth History
                 10:55 a.m. - Tectonophysics, Deep Crust and Mantle Dynamics

11:40-11:50 a.m.  OPEN/Travel Time

11:50 a.m.-1:00 p.m. Lunch at local restaurant

1:00-2:45 p.m.    Meet with Students (327 Halbouty)
                 1:00 p.m. - Undergraduate students
                 1:35 p.m. - Masters students
                 2:10 p.m. - Ph.D. students and Postdocs

2:45-3:10 PM     OPEN

3:10 -3:50 p.m.   Meet with Junior Faculty (Assist. & Assoc. Professors; 327 Halbouty)

3:50-5:00 p.m.    Meet with Selected Faculty Committees (327 Halbouty)
                 3:50 p.m. - Graduate Admissions and Recruiting Committee
                 4:25 p.m. - Tenure and Promotion Committee

5:00 p.m.        Review team escorted to Reveille Inn by Andreas Kronenberg

5:30-6:30 p.m.    Dinner catered at Reviewers’ hotel workroom

6:30             Reviewers’ work session, preparation of draft report for exit interview, and faculty debriefing
Day 3 (Tuesday, January 27, 2010)

7:30-9:00 a.m. Exit interview at the Reveille Inn with Interim Executive Vice President for Academics and Provost, Karan Watson, Vice Provost, Martyn Gunn, Interim Dean of Graduate Studies, Robert Webb, Interim Associate Provost for Undergraduate Studies, Pamela Matthews, Dean of College, Kate Miller, and Reviewers.

Breakfast served. Reviewers present summary of their on-site review.

Review team escorted to the Halbouty Building.

9:00-9:20 a.m. OPEN/Travel time (bring luggage to campus)

9:20-10:10 a.m. Reviewers debrief Department Head (354 Halbouty)

10:10-11:00 a.m. Reviewers make final changes to draft report, as necessary (354 Halbouty)

11:00 a.m.-12:00 Reviewers brief Faculty and Students on final report (101 Halbouty)

12:00-1:00 p.m. Lunch with Department Head and Faculty in 354 Halbouty (catered)

1:00-3:00 p.m. Reviewers depart College Station. Escorted to airport by Department Head
Chapter 2 – Departmental Overview

2.1 History of Department

Texas A&M University

Texas A&M University (TAMU) is the oldest public institution of higher learning in Texas, predating the University of Texas by seven years. Established in 1876 as an all-male military college, named the Agricultural and Mechanical College of Texas, it is now among the largest research universities in the nation, with a student body of over 48,000, of which 9,100 are graduate students, and a faculty of over 2,800. The Corps of Cadets is still an active part of the student population, but membership is not compulsory and the campus has been coeducational since 1963.

TAMU is designated as a land grant university (http://www.tamu.edu/) and it also has the distinctions of being a sea grant and a space grant institution. The Texas A&M System endowment is valued at $6.7 billion. TAMU annual research expenditures for 2008 exceeded $580M, placing it in the top 20 academic research performers by the National Science Foundation in October, 2009. In the U.S News and World Report survey of Dec. 1, 2009, TAMU has been ranked 61st of all research universities of the United States and 22nd of all public universities.

In 1997, Texas A&M initiated a process of self-examination leading to the university's Vision 2020 plan to become one of the top ten public research universities in the country. This led to concrete proposals for faculty hiring under the University's Faculty Reinvestment Initiative and over 450 new faculty hires have been made across campus since 2003, in addition to replacing faculty losses. Current initiatives are in progress to foster interdisciplinary research, improve the assessment of our academic programs and their outcomes, increase international and undergraduate research experiences, and increase the diversity of TAMU faculty and students.

Department of Geology and Geophysics

The first geology course taught at TAMU was offered in 1903 in the Department of Chemistry and Mineralogy, just two years after the January 10, 1901 Spindletop discovery near Beaumont, Texas. The current department (http://geoweb.tamu.edu/) has its origins in the Department of Geology established in 1922 in the School of Engineering, initiated with two faculty members and twelve course offerings. The first geology undergraduate bachelor degrees were granted in 1930. The first graduate level courses were offered during the 1928-1929 academic year, and the first graduate degree, a Masters of Science in Petroleum Geological Engineering, was granted in
1931. This degree was awarded to a young Mr. Michel T. Halbouty, who later became one of the department's benefactors; his thesis was on the "Geology of Atascosa County, Texas."

Geophysics was introduced to the curriculum and course offerings in geophysical methods were steadily increased during the 1950s, ultimately leading to the first B.S. in Geophysics in 1957. The first M.S. in Geology was awarded in 1951 and the first M.S. in Geophysics was awarded in 1959. Doctoral degrees in both Geology and Geophysics were first conferred in 1959. The department was renamed the Department of Geology and Geophysics in 1964 as the School of Engineering became the College of Engineering. It was then split into two departments, the Department of Geology and Geography and the Department of Geophysics in 1965 as academic units of the newly formed College of Geosciences. In 1969, Geography became its own department. The Departments of Geology and Geophysics were merged again in 1995.

With its origins in a school of engineering, the department has always had an emphasis on geological applications. As members of a research university, we are interested in both applications and in fundamental understanding and discovery. The TAMU Geology curriculum has always emphasized strong math and science backgrounds. In the 1950s, the Geology major required two years of math, one year of precalculus and one year of calculus. Today, we require two years of calculus through differential equations. We continue to offer field-based courses to our undergraduate and graduate students, in addition to laboratory and problem-solving courses.

Since our last review in 2002, we have been able to grow from 26 FTE faculty to 32, owing to the University's Reinvestment Program and ODASES initiative. This is in spite of several faculty losses. Our undergraduate student numbers have doubled in the last four years and our graduate student numbers have recently rebounded. In the most recent (2006) ranking of graduate Earth science programs by the U.S. News and World Report, TAMU Geology and Geophysics ranked 34th nationwide and 22nd of all departments at state universities. We currently have five postdoctoral fellows, which is unprecedented in the history of our department.

The Department of Geology and Geophysics is housed in the Halbouty Geosciences Building, built in 1932 and originally named the Petroleum Engineering, Geology, and Engineering Experiment Station Building. A new wing was added and the building was renovated in 1983. It features beautiful wrought iron trilobites and stained glass crystal forms, and yet this historic building presents a number of infrastructure and maintenance challenges.
2.2 Statement of Department Mission & Goals

Texas A&M University is a comprehensive teaching and research university of the State of Texas, and it is the leading institution of the Texas A&M University System. The goal of the university is to serve the public good through teaching, research, and service to society.

The Department of Geology and Geophysics is dedicated to the scientific study of all aspects of the solid Earth, from fundamental processes that shape it to knowledge that benefits society. The objectives of our undergraduate programs are to provide students with a comprehensive education, emphasizing critical thinking, scientific, mathematical and communication skills, and fundamental understanding in the fields of geology and geophysics. The B.S. degrees are intended to provide students with a rigorous background that initiates their careers in the Earth sciences while the B.A. in Geology is intended to give students greater flexibility to pursue a wide range of interests and career choices, while focusing their major studies in geology.

Graduate education and scientific research are inseparable, as we prepare graduate students for careers in geology and geophysics, and we attempt to make scientific breakthroughs that lead to better understanding of the planet and applications that benefit society. The objectives of our Masters programs are to provide a strong foundation for professional geologists and geophysicists and to develop the student's problem solving skills through advanced course work and original research leading to a thesis. In our Ph.D. programs, we further aim to develop the student's ability to lead original research and ask critical questions that shape scientific thought. An important goal of all of our graduate programs is to develop communication skills, both orally and in writing. Results of research are communicated through journal publications, presentations at national and international meetings, and reports submitted to industry and government agencies.

As members of a research university, faculty also engage in governance of Texas A&M University, at department, college, and university levels, and in service to the scientific community and in outreach to society. Our service goals are met by administrative and educational efforts on and off campus, contributing to educational methods in the geosciences, participation on committees of professional societies, membership on funding panels, and participation in scientific and educational workshops.

We are committed to assisting Texas A&M University and the State of Texas in their missions. The Department of Geology and Geophysics offers introductory courses in geology that fulfill broadening core requirements for non-science majors across campus. Because understanding the geology of the Earth involves applications of physics, chemistry and biology, our introductory courses expose students to a wide range of scientific principles.
2.3 Summary of 2002 External Program Review

The Department of Geology and Geophysics received an external review of its Ph.D. program in 2002. In their Feb. 26, 2002 report (Appendix I), the External Review Committee, chaired by Dr. W. Gary Ernst, also included a more general review of the department. This section briefly reviews the state of the department at that time and the principal conclusions of the review.

Faculty and Research Staff

In 2002 the Department of Geology and Geophysics had 26 full time faculty members, with six additional faculty who held joint appointments in Oceanography, Geography, and Petroleum Engineering (Table 2.1), as well as one lecturer, a research scientist who taught some courses, and one postdoctoral researcher. This represented a significant reduction from 37 full time equivalent (FTE) faculty members when the two separate Departments of Geology and Geophysics were merged, eight years before. Of the full time faculty members, 18 were full Professors, five were Associate Professors, and three were Assistant Professors.

Of the full-time tenure-track and tenured members in the department in 2002, 20 are still in the department, our Lecturer was promoted to Assistant Professor, and our Associate Research Scientist was promoted to Associate Research Professor. Of the Joint Faculty appointments in 2002, four are currently with TAMU and of these, two are administratively part of the department. Two full time faculty members left TAMU for other career opportunities and four were awarded Emeritus upon their retirement. The Curricula Vitae of continuing faculty, along with those of all current faculty members, are provided in Appendix A.

Students

In 2002, just over 200 students were enrolled in academic programs offered by the department. At the undergraduate level, there were about 100 geology majors and a dozen geophysics majors. At the graduate level, 40 students were pursuing a M.S. in geology, 16 were working on a M.S. in geophysics, and a little over 40 students were working towards doctoral degrees, almost evenly split between geology and geophysics.

Staff

In 2002, the Geology and Geophysics office staff consisted of four administrative assistants, who took care of appointments, administrative records, financial matters, accounting, and support of undergraduate and graduate programs. Two IT staff members assisted faculty and students with network and computer needs, as well as maintenance of a departmental website and preparation of an annual alumni newsletter. Introductory laboratories were organized and teaching assistants
Table 2.1. Faculty Members of Department of Geology and Geophysics in 2002 and Faculty Status in 2009

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<tr>
<th>Name</th>
<th>2002 Title</th>
<th>Field</th>
<th>2009 Status</th>
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<tbody>
<tr>
<td>Wayne Ahr</td>
<td>Professor</td>
<td>Carbonate Sedimentology</td>
<td>Professor</td>
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<tr>
<td>Rick Carlson</td>
<td>Professor</td>
<td>Geodynamics/Tectonics</td>
<td>Leave/NSF</td>
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<tr>
<td>Fred Chester</td>
<td>Professor</td>
<td>Tectonophysics/Struct. Geol.</td>
<td>Professor</td>
</tr>
<tr>
<td>Judith Chester</td>
<td>Assist. Prof.</td>
<td>Tectonophysics/Struct. Geol.</td>
<td>Assoc. Prof.</td>
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<tr>
<td>Steve Dorobek</td>
<td>Professor</td>
<td>Carbonate Sed./Stratigraphy</td>
<td>Left TAMU</td>
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<tr>
<td>Mark Everett</td>
<td>Professor</td>
<td>Electromagnetic Geophysics</td>
<td>Professor</td>
</tr>
<tr>
<td>P. Jeff Fox</td>
<td>Joint Prof/Dir. ODP</td>
<td>Tectonics</td>
<td>Joint Prof./Ocean</td>
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<tr>
<td>Rick Giardino</td>
<td>Joint Prof/Dean OGS</td>
<td>Geomorphology/Engin. Geol.</td>
<td>Joint Prof./Geog</td>
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<tr>
<td>Rick Gibson</td>
<td>Assoc. Prof.</td>
<td>Seismology</td>
<td>Assoc. Prof.</td>
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<tr>
<td>Ethan Grossman</td>
<td>Professor</td>
<td>Isotope Geochemistry</td>
<td>Professor</td>
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<tr>
<td>Andy Hajash</td>
<td>Head/Professor</td>
<td>Aqueous Geochemistry</td>
<td>Professor</td>
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<tr>
<td>Bruce Herbert</td>
<td>Assoc. Prof.</td>
<td>Environ. Biogeochemistry</td>
<td>Prof./Asst.Head</td>
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<tr>
<td>Tom Hilde</td>
<td>Professor</td>
<td>Geodynamics/Marine Geophys.</td>
<td>Retired</td>
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<tr>
<td>Luc Ikelle</td>
<td>Professor</td>
<td>Petroleum Seismology</td>
<td>Professor</td>
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<tr>
<td>Jerry Jensen</td>
<td>Joint Prof/Pet Eng.</td>
<td>Reservoir Character</td>
<td>Left TAMU</td>
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<td>Brann Johnson</td>
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<td>Tectonophysics/Struct. Geol.</td>
<td>Retired</td>
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<tr>
<td>Andreas Kronenberg</td>
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<td>Tectonophysics/Mineral Phys.</td>
<td>Prof./Head</td>
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<tr>
<td>Will Lamb</td>
<td>Assoc. Prof.</td>
<td>Metamorphic Petrology</td>
<td>Assoc. Prof.</td>
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<tr>
<td>Chris Mathewson</td>
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<td>Engineering Geology</td>
<td>Professor</td>
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<tr>
<td>Julie Newman</td>
<td>Lecturer</td>
<td>Structural Geol/Tectonophysics</td>
<td>Assist. Prof.</td>
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<tr>
<td>Bob Popp</td>
<td>Professor</td>
<td>Mineralogy/Geochemistry</td>
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<tr>
<td>Phil Rabinowitz</td>
<td>Professor</td>
<td>Marine Geophysics/Geology</td>
<td>Retired</td>
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<tr>
<td>Anne Raymond</td>
<td>Professor</td>
<td>Paleobotany, Paleogeography</td>
<td>Professor</td>
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<tr>
<td>MaryJo</td>
<td>Joint Prof/Assoc Dean</td>
<td>Marine Geology</td>
<td>Joint Prof./Ocean</td>
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<td>Name</td>
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<td>2009 Status</td>
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<td>Richardson</td>
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<tr>
<td>Jim Russell</td>
<td><em>Joint Prof/Petrol. Eng.</em></td>
<td>Tectonophysics/Mechanics</td>
<td><em>Retired</em></td>
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<tr>
<td>Will Sager</td>
<td><em>Joint Prof/Ocean.</em></td>
<td>Paleomagnetism/Tectonics</td>
<td><em>Joint Prof/Ocean.</em></td>
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<tr>
<td>John Spang</td>
<td>Professor</td>
<td>Tectonophysics/Struct. Geol.</td>
<td>Professor</td>
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<tr>
<td>David Sparks</td>
<td>Assoc. Prof.</td>
<td>Geodynamics/Tectonophysics</td>
<td>Assoc. Prof.</td>
</tr>
<tr>
<td>Joel Watkins</td>
<td>Professor/Emeritus</td>
<td>Petroleum Geophysics</td>
<td><em>Retired</em></td>
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<tr>
<td>Brian Willis</td>
<td>Assoc. Prof.</td>
<td>Stratigraphy</td>
<td><em>Left TAMU</em></td>
</tr>
<tr>
<td>Dave Wiltschko</td>
<td>Professor</td>
<td>Tectonophysics/Struct. Geol.</td>
<td>Professor</td>
</tr>
<tr>
<td>Tom Yancey</td>
<td>Professor</td>
<td>Paleontology/Environ/Climate</td>
<td>Professor</td>
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<tr>
<td>Hongbin Zhan</td>
<td>Assoc. Prof.</td>
<td>Hydrogeology</td>
<td>Professor</td>
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</table>

were supervised by a Technical Lab Coordinator. The department supported just one Laboratory Research Specialist.

**Salient Points of the 2002 Review**

At the time of the 2002 Program Review, Texas A&M University had recently completed a long-range planning effort known as Vision 2020 with the goal of elevating Texas A&M to a top-ten public university in national rankings by the year 2020. The Vision 2020 plan established twelve imperatives for the university:

1. Elevate our faculty and their teaching, research and scholarship
2. Strengthen our graduate programs
3. Enhance the undergraduate academic experience
4. Build the letters, arts, and sciences core
5. Build on the tradition of professional education
6. Diversify and globalize the A&M community
7. Increase access to knowledge resources
8. Enrich our campus
9. Build community and metropolitan connections
10. Demand enlightened governance and leadership
11. Attain resource parity with the best public universities
12. Meet our commitment to Texas
The Charge of the 2002 Geology and Geophysics External Review was focused on the Ph.D. program and on meeting the challenge of Vision 2020 to gain recognition as one of the top ten academic programs. In their evaluation of the Department, the External Review Committee addressed: 1) faculty stature and academic performance, 2) strength of the Ph.D. (and M.S.) programs, and 11) research funding and facilities. Their report included a number of perceived strengths and weaknesses, along with recommendations to build on strengths and resolve weaknesses.

**Strengths:**

I. The department had visibility in the petroleum industry as a major educational and research unit, with internship and career opportunities for students.

II. The department enjoyed a unique relationship with its former students, many of whom were involved in the energy industry and provided significant contributions to the department and students.

III. Facilities and equipment were abundant and teaching facilities were excellent. State-of-the-art capabilities were recognized in rock deformation.

IV. Students had access to state-of-the-art computational facilities, common space, and financial support through fellowships and teaching assistant positions.

V. Faculty had across-the-board strengths in a wide range of research areas, with notable strengths in petroleum geosciences and tectonophysics, and potential in environmental geosciences.

VI. Excellent new faculty had been hired with significant potential in teaching and research.

VII. Unusual potential for synergism was recognized with other departments in a College of Geosciences, and with the Ocean Drilling Program.

**Weaknesses:**

i. The department appeared to lack a clear focus with a unified, inclusive vision for the future and high-impact research objectives.

ii. Graduate student capabilities and interests were not commensurate with those of a top-tier research university.

iii. The graduate student applicant pool was inadequate in terms of quality and quantity.

iv. Long residence times and failure of graduate students to focus on research were attributed to the structure of the graduate program, teaching assistant duties and summer internships.

v. The overall level of research funding was not competitive with nationally ranked research universities.
vi. The department did not have a critical mass of senior faculty who were leading collaborative, interdisciplinary research efforts.

vii. The department did not have sufficient state-of-the-art analytical equipment to compete with research efforts of top-tier departments.

Recommendations:

a. Define a new compelling vision for scientific research and education. Such a vision will involve one or two major crosscutting intellectual themes that have societal impact.

b. Build on scientific visibility and fund-raising potential, with support from former students of the department.

c. Develop a strategic hiring plan that will reach the objectives of the new research directions, with emphasis on recruiting bright young faculty and aid existing faculty in obtaining extramural research support.

d. Define and recruit transforming individuals who can lead the intellectual themes of the department.

e. Reassess the structure of the graduate program, recognizing the contrasting needs of both professional students and research-oriented students. While professional students represent a link between the department and industry, the quality and quantity of research-oriented M.S. and Ph.D. students will determine the success of the department in reaching the Vision 2020 goal.

f. Take steps to upgrade the overall quality of graduate students and the graduate program, including increases in entry standards, aggressive recruiting, and offering competitive financial packages.

g. Budgets and resources should be structured to reward research quality and productivity.

h. Develop a long-term plan for acquisition of state-of-the-art instrumentation and support facilities. When possible, state-of-the-art facilities should be developed as shared facilities of the College.

Strategic Planning following Review

The 2002 External Review initiated significant faculty discussion and debate, leading to a faculty retreat and the preparation of a Strategic Plan, which was submitted to the College of Geosciences in 2005 (Appendix J). Additional, informal research seminars were held in order to focus on our research strengths and explore our research opportunities. While the challenge of identifying a single scientific theme for the diverse faculty of the department was not met, several interdisciplinary research areas were identified. These included petroleum geosciences,
environmental geosciences, and tectonophysics, all of which were recognized as existing strengths of the department. In addition, we concluded that paleoclimate and continental margins research could flourish, given our affiliations and common research interests with faculty and scientists of Oceanography, Atmospheric Sciences, and the Ocean Drilling Program. Societal impact was recognized in all of these areas, with applications for energy, environment, and hazards.

With the department's scientific visibility in the energy industry, the faculty agreed that petroleum geosciences needed to be reinforced. The department met with the Geology and Geophysics Advisory Council (GEODAC), consisting of former students and representatives of the energy industry, in workshops that employed emergent learning methods used in industry strategic planning.

As part of the 2005 Strategic Plan, the department prioritized faculty hiring to build strengths in highly visible and well-funded research areas. New faculty positions were proposed to build the department's education and research capabilities in the following areas:

- **Petroleum Geosciences** - Seismology and Interpretation, Petroleum Systems Studies, Reservoir Modeling
- **Environmental Geosciences** - Hydrogeology (field observational), Biogeochemistry, Organic Geochemistry
- **Tectonophysics** - Earthquake Source Physics, Mechanics of Granular Media, Tectonic Geodesy
- **Climate Change** - Isotope Geochemistry and Paleoceanography, Paleoclimate Modeling, Open Ocean Micropaleontology
- **Continental Margins** - Seismology, Mechanics of Granular Media

Many of these research areas could be developed with new faculty in Geology and Geophysics by working with faculty and scientists from other departments, programs and centers in the College of Geosciences. The greatest need for senior faculty was identified in the petroleum geosciences, partly because of the experience necessary, and partly to provide leadership in interdisciplinary approaches to petroleum systems studies.

The challenge posed by the 2002 External Review of maintaining a M.S. program for professional geology students and a Ph.D. program for research-oriented students was discussed at length. While choosing to focus on one or the other program may be a simple solution, the faculty concluded that publishable research papers should result from both M.S. and Ph.D.
programs. Workshops held with the Department's advisory council confirmed that communication skills, and the capability to solve challenging new problems are highly valued in industry, just as they are in academia.

The 2002 Review Committee was troubled by the caliber of our graduate students. In response, the faculty resolved to increase its entrance requirements and improve its graduate student recruiting efforts. In addition, the decision was made to attract postdoctoral geoscientists to the Department, making use of earnings from the department's endowments, with the goal of improving the research environment and providing mentors to our Ph.D. (and M.S.) students.

The 2002 review concluded that research funding and state-of-the-art analytical facilities were insufficient to reach the objective of Vision 2020 of becoming a top-ten geoscience department. Examination of research funding throughout the Department revealed that funding opportunities are inhomogeneous and that some faculty have more opportunities than others to support their research efforts. Faculty resolved to seek new sources of funding, and to consider funding potential in new faculty hires. Needed improvements to existing laboratory facilities were reviewed and new analytical laboratories in environmental and isotope geochemistry were identified along with needs for technical support.

In addition to those Vision 2020 Imperatives considered during the 2002 External Review, our 2005 Strategic Plan addressed our undergraduate programs (Imperative 3), core courses designed for non-science majors (Imperative 4), building a culture of shared governance (Imperative 10), improving diversity in our faculty and students (Imperative 6), and meeting our commitments to the state of Texas (Imperative 12). The Department resolved to enhance undergraduate programs by incorporating field observations into a number of courses, as well as by building and maintaining our field methods and summer field courses. We have addressed means of improving communication and math skills of our students, and providing undergraduate research and internship opportunities. The Department plays a major role in providing core science courses at TAMU and is attempting to increase the population of underrepresented students in geology and geophysics majors. The Department has worked to build a culture of shared governance, through open discussion, consensus-building, sharing responsibilities on faculty committees, and calling for votes on important matters. Our petroleum and environmental geosciences are intended to meet needs of the state of Texas.
2.4 Changes since 2002 and Current State of the Department

Faculty

In the time since the last External Review, the Department has experienced significant changes in its faculty, with large numbers of losses and gains in FTE faculty (Table 2.2) as well as appointments of joint and adjunct faculty. When Dr. Watkins retired in 2002, we recognized the need to rebuild research in petroleum geophysics and to continue offering courses in reflection seismology and interpretation. In 2005, the Department hired Dr. Hopper, an outstanding reflection seismologist with interests in continental rifting and margin architecture, and in 2007, we hired Dr. Sun who strengthened our program significantly, both in petroleum geology and geophysics.

In 2006, the Department suffered losses in our sedimentary and petroleum geology programs, as Drs. Dorobek and Willis left to accept petroleum industry positions. With this reduction in our faculty representation of sedimentology and stratigraphy at a time that student interest in these areas was increasing, we were not able to accept student applicants in these fields, as our pool of appropriate advisors had been reduced to one faculty member. The Department had the good fortune to have Dr. Bouma return to TAMU as an adjunct professor in 2006. Dr. Bouma offered graduate courses in sedimentology and stratigraphy and helped Dr. Ahr advise resident graduate students completing thesis research in sedimentary geology. We also benefited from our contacts in the energy industry and affiliations with IODP. In the fall semester of 2007, Dr. Art Donovan offered his time and expertise to our program (his employer, BP America, offered release time) to teach our graduate course in sequence stratigraphy (Geol 622) at no cost to TAMU. This course was inspiring to our students and we offered Dr. Donovan an adjunct position in the department. In the spring semester of 2008, we were able to offer our undergraduate sedimentology and stratigraphy course (Geol 306) thanks to the efforts of IODP research scientist, Dr. Cedric John. The Department was able to offer a graduate seminar on basin analysis (Geop 681) in spring, 2009, with the generous support of numerous Ph.D. geoscientists from Anadarko, BP, Devon, and Marathon, who gave outstanding talks that revealed current exploration and development strategies, and provided in-class exercises using rich, unpublished industry data sets. Thus, our ability to offer students excellent courses was not diminished. However, the loss of two excellent sedimentary geologists from the department and the failure to replace them quickly contributed to concern by our industry colleagues that we had not prioritized our graduate program in petroleum geosciences.

Over the years, 2003 to 2008, we lost three senior faculty members to retirement, and gained new tenure-track faculty, Drs. Miller, Newman and Olszewski. In 2008, the Department lost two active young faculty members to other institutions. Dr. Hopper's loss was deleterious to our petroleum geoscience program; we continue to offer our graduate seismic interpretation course
but are limited in geophysics advisors and must search for a replacement. Dr. McGuire's loss has been felt in our environmental geosciences program. The Department also gained recently as outstanding joint faculty members of the department, Drs. Fox and Giardino, stepped down from their administrative positions and began to contribute to the department's mission full time.

University Priorities: ODASES and Faculty Reinvestment Programs

Two new initiatives of the university contributed to the Department's ability to build on the strengths we identified in our 2005 Strategic Plan. The Ocean Drilling and Sustainable Earth Science (ODASES) initiative was proposed by TAMU as part of the new Integrated Ocean Drilling Program (IODP). This initiative allowed us to search for new faculty in areas of micropaleontology, paleoclimate, paleoceanography, and mechanics of granular ocean sediments. We successfully recruited Dr. Bridget Wade to our department, whose studies of microfossils bear on paleoclimate, and we gained a joint member of the faculty, Dr. Debbie Thomas, who investigates paleoceanography and holds her primary appointment in the Oceanography Department.

With the Faculty Reinvestment Program, the Department was authorized to hire new faculty. Historically, tuition and fees at public universities in Texas have been low compared with national averages. Over the years, this helped make a university education affordable to Texas residents, but it also led to compromises in educational quality, limiting student access to faculty, and to deferred maintenance of university buildings and facilities. Steady annual increases in student enrollments further contributed to a poor student-to-faculty ratio. In order to finance the Faculty Reinvestment, Texas A&M University was allowed to increase its tuition; yet, current tuition and fees at TAMU are still relatively low (about $8,300 annually for residents). Of the 450 new faculty hires across campus, our department was authorized to add four new faculty members, beyond normally justified faculty replacements.

Intensive faculty searches in those areas we chose to build in our 2005 Strategic Plan led to outstanding hires of new faculty members, Drs. Duan, Marcantonio, Tice, and Weiss, who added new expertise to our graduate programs in geophysics and tectonophysics, geochemistry and paleoceanography, environmental geochemistry and geobiology, and sedimentology and dynamic sediment transport. Notably, we identified outstanding candidates in hydrogeology, granular mechanics, and tectonic geodesy, who could have contributed to our strengths in environmental geosciences and tectonophysics, but we were unable to make timely, competitive offers.
Table 2.2. Department of Geology and Geophysics full time equivalent (FTE) faculty since 2002

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<th>Spring 03</th>
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<td>Chester P</td>
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Reinvestment/ODASES Hires

- Duun: Assoc Prof
- Marcantonio: Assoc Prof
- Tice: Assistant Prof
- Wade: Assistant Prof
- Weiss: Assistant Prof
Rebuilding Sedimentary Geology and Petroleum Geoscience Programs

With the addition of Drs. Tice and Weiss to our faculty, we added considerably to the department's strength in fundamental studies of sediment transport, deposition, and biogeochemistry, but we still needed to rebuild our applied science capabilities in sedimentary geology. Once all reinvestment hiring was completed, the Department was approved by the College of Geosciences to make replacement hires in sedimentology and stratigraphy. Last year's faculty search led to the addition of Dr. Pope to our faculty, with interests in applied and fundamental problems in stratigraphy, and a concerted effort to hire a leading senior-level stratigrapher, Dr. Mancini, with interests in basin-scale stratigraphy and reservoir systems. With the assistance of Dr. Mancini, and support of the department's advisory council and college, a concept paper and proposal were submitted to Texas A&M's Board of Regents to establish a new center of excellence. With contributions of over $2.9M towards a permanent endowment, the Berg-Hughes Center for Petroleum and Sedimentary Systems has been established, with Dr. Mancini arriving in January, 2010 as its first director. Dr. Mancini has a record of building successful research teams and he has plans to initiate interdisciplinary studies that involve geologists, geophysicists, and petroleum engineers at TAMU and research scientists in the energy industry.

Current Faculty

Gains in faculty through ODASES and Reinvestment initiatives have been moderated by greater faculty losses than faculty replacements. Nevertheless, the Department has grown to 32 FTE faculty at the time of this review (Figure 2.1), of which 18 are full Professors, nine are Associate Professors, and five are Assistant Professors (Table 2.3). In addition to tenured and tenure-track faculty, the department has one Associate Research Professor who operates and maintains the microprobe facility and offers some graduate courses. The Department has six joint faculty members with adlocs in other departments, and ten adjunct faculty members. The Department of Geology and Geophysics serves as the academic home of the Department Head and the Dean of Geosciences, but these positions have adlocs with the College of Geosciences. Brief curricula vitae of all current faculty appear in Appendix A.

While the research interests of individual faculty remain diverse, our internal self study identifies existing and emerging strengths in:

1. Petroleum Geology and Geophysics
2. Water Resources and Environmental Geosciences
3. Tectonophysics, Deep Crust and Mantle Dynamics
4. Life, Climate, and Earth History
These are areas emphasized by our graduate curricula (Appendix C), addressed by published research (Appendix D), and funded by research grants (Appendix E). Our research interests in petroleum geosciences have potential for funding by the energy industry and the U.S. Department of Energy (DOE). Our research interests in water, environment, tectonophysics, deep Earth processes, and the history of life and climate align well with challenges identified in the NSF GeoVision Report of October, 2009 (http://www.nsf.gov/geo/acgeo/geovision/start.jsp).

Table 2.3. Faculty Members of Department of Geology and Geophysics, Sept 2009

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<td>Petrol. Engin.</td>
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<td>Anne Raymond</td>
<td>Professor</td>
<td>Paleobotany, Paleogeography</td>
<td></td>
</tr>
<tr>
<td>MaryJo Richardson</td>
<td>Joint Professor</td>
<td>Marine Geology</td>
<td>Oceanography</td>
</tr>
<tr>
<td>Will Sager</td>
<td>Joint Professor</td>
<td>Paleomagnetism/Tectonics</td>
<td>Oceanography</td>
</tr>
<tr>
<td>John Spang</td>
<td>Professor</td>
<td>Tectonophysics/Struct. Geol.</td>
<td></td>
</tr>
<tr>
<td>David Sparks</td>
<td>Assoc Prof.</td>
<td>Geodynamics/Tectonophysics</td>
<td></td>
</tr>
<tr>
<td>Yuefeng Sun</td>
<td>Assoc. Prof.</td>
<td>Petroleum Geology and Geophys</td>
<td></td>
</tr>
<tr>
<td>Vatche Tchakerian</td>
<td>Joint Professor</td>
<td>Geomorphology</td>
<td>Geography</td>
</tr>
<tr>
<td>Debbie Thomas</td>
<td>Joint Assist. Prof.</td>
<td>Paleooceanography</td>
<td>Oceanography</td>
</tr>
<tr>
<td>Michael Tice</td>
<td>Assist. Prof.</td>
<td>Geobiology/Sedimentology</td>
<td></td>
</tr>
<tr>
<td>Jack Vitek</td>
<td>Adjunct Prof.</td>
<td>Geomorphology</td>
<td></td>
</tr>
<tr>
<td>Bridget Wade</td>
<td>Assist. Prof.</td>
<td>Micropaleontology/Climate</td>
<td></td>
</tr>
<tr>
<td>Robert Weiss</td>
<td>Assist. Prof.</td>
<td>Tsunami/Sediment Transport</td>
<td></td>
</tr>
<tr>
<td>Dave Wiltschko</td>
<td>Professor</td>
<td>Tectonophysics/Struct. Geol.</td>
<td></td>
</tr>
<tr>
<td>Tom Yancey</td>
<td>Professor</td>
<td>Paleontology/Environ/Climate</td>
<td></td>
</tr>
<tr>
<td>Hongbin Zhan</td>
<td>Professor</td>
<td>Hydrogeology</td>
<td></td>
</tr>
</tbody>
</table>

*Postdoctoral Fellows and Research Scientists*

The Department has successfully recruited postdoctoral fellows and research scientists (Table 2.4) who work with faculty and students, funded by endowments and extramural funding (from NSF and USGS) in geophysics and tectonophysics, paleobiology, environmental biogeochemistry, and geoscience education. We are proud of our postdoctoral scientists, for their research productivity, contributions to student mentoring, and participation in life of the department. Dr. Jason Moore is second author to a recent publication in *Science* (Varricchio et al., 2008), and all five have contributed to research proposals (submitted to NSF, SCEC, and TARP).
Table 2.4. Postdoctoral Fellows and Research Scientists of Department of Geology and Geophysics, Sept 2009

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Field</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caleb Holyoke</td>
<td>Assist Res. Sci.</td>
<td>Rock Deformation/Microstruct</td>
<td>NSF</td>
</tr>
<tr>
<td>Hye-Jeong Kim</td>
<td>Postdoc. Fellow</td>
<td>Science Education</td>
<td>NSF</td>
</tr>
<tr>
<td>Jason Moore</td>
<td>Postdoc. Fellow</td>
<td>Quantitative Paleobiology</td>
<td>Harris Endowmt</td>
</tr>
<tr>
<td>Fabio Sartori</td>
<td>Postdoc. Fellow</td>
<td>Biogeochemistry/Soil Science</td>
<td>Harris Endowmt</td>
</tr>
<tr>
<td>Jinquan Zhong</td>
<td>Postdoc. Fellow</td>
<td>Earthquake Rupture Modeling</td>
<td>USGS/NSF</td>
</tr>
</tbody>
</table>

*Students*

Since the 2002 External Review, the population of undergraduate students majoring in Geology and Geophysics at Texas A&M University remained relatively steady at just over 100 majors until 2006, when our student numbers began to increase to today's record of 219 majors (*Figure 2.2*). Graduate student numbers showed a slow 10-15% decline (to ~100) from 2002 to 2005, and then dropped significantly, corresponding to our faculty losses in sedimentary geology and the loss of our department web designer. Graduate student numbers began to recover (from a low of < 80) as we rehired sedimentology and stratigraphy faculty and college IT staff supported our recruiting efforts with significant improvements to the department website. We currently have 111 graduate students, which is near our historical average. However, most of these students are Masters candidates and we still have relatively few (~35) Ph.D. students.

The Department has continued to maintain a strong commitment to introductory core science courses at Texas A&M University, with undergraduate student credit hours of over 12,000 per year (*Figure 2.3*). Student credit hours in required courses of the geology and geophysics majors have grown, corresponding to our increasing student numbers, while graduate student credit hours have changed little.
**Departmental Staff**

The number of administrative staff members of the Department is unchanged from 2002 (*Figure 2.1*), with modest gains and losses of technical staff members. The department lost its IT communications staff member in 2004, which signaled the end of the department's alumni newsletter, and the transfer of web services to college IT personnel. The department's website languished for over two years before new college IT personnel were hired and were able to update departmental websites of the college. Following this unfortunate delay, recent web service and public communications by the college staff have been outstanding. Organizationally, the remaining department computer IT specialist, Mr. Steve Tran, was transferred to the College of Geoscience, but he continues to manage the department's server and network. A new microcomputer specialist, Mr. Ryan Young, was hired during the 2006-2007 academic year to assist with faculty and student requests. Both IT personnel are excellent and they have met all of our computational and network needs.

Dr. Michael Heaney organizes our Introductory Geology laboratories and supervises teaching assistants. In addition, Dr. Heaney organizes and teaches the department's field methods and summer field geology courses (Geol 309 and 300, respectively). The Department hired a new laboratory technician for the John Handin Rock Deformation Laboratory, upon retirement of our senior Research Specialist, in support of graduate teaching and research functions of the Center for Tectonophysics. The Department also hired, and later lost, a technician in support of geochemistry and environmental geosciences education and research. A search is underway to hire a new geochemistry technician, in support of the new radiogenic isotopes laboratory. The

**Figure 2.2. Geology and Geophysics Student Enrollment since 2002.**
Department hired a building proctor in spring 2008 with responsibilities for security, maintenance, health, safety, and inventory of the building, but we will need to refill this position in spring, 2010.

![Annual Semester Credit Hours](image)

**Figure 2.3. Undergraduate and Graduate Semester Credit Hours since 2002**

*Space and Facilities*

The 2002 External Review concluded that the Department was well situated in the Halbouty Geosciences Building with pleasant open spaces, excellent teaching facilities, a well maintained electron microprobe, state-of-the-art computational facilities, and a unique rock mechanics laboratory. However, our analytical laboratory instrumentation and facilities fell short of the review committee's expectations for a top-tier research department.

Classroom and laboratory instructional facilities continue to be updated and maintained through TAMU Classroom Instructional Technology (CIT) grants and funds generated by Instructional Enhancement/Equipment Fees (IE/EF). Our electron microprobe is now 20 years old and we have submitted a NSF MRI proposal to replace it with the latest generation instrument. We have continued to upgrade our computational facilities for geophysical data analysis, high speed and 3D visualization, and numerical modeling. However, the building's infrastructure to cool our computational facilities has not been upgraded, as college priorities shifted to support a centralized computational data center. Excellent new environmental geochemistry and geobiology laboratories have been initiated in the Department and several research optical microscopes with high resolution image capture capabilities have been acquired. Sedimentary geology laboratories and core facilities are scheduled to be rebuilt in support of research in the
new Berg-Hughes Center. However, the John Handin Rock Deformation Laboratory, established over 40 years ago, is in need of major upgrades.

A state-of-the-art isotope geochemistry laboratory has recently been established in the Halbouty Geosciences Building, which is a college-wide asset and has been endowed through a major contribution to the College. The R. Ken Williams Radiogenic Isotope Geosciences Laboratory features class 100 and 1000 ultra-clean lab sample processing, and two high-end mass spectrometers, a TIMS and a high-resolution ICP-MS. The stable isotope laboratory that was in the Halbouty Building in 2002 has been moved to the Oceanography and Meteorology Building, combining its capabilities with those of other laboratories of the Departments of Oceanography and Geography. This college-wide laboratory now features three mass spectrometers, two of which are recent acquisitions. A 3D visualization laboratory funded as a university-wide facility is housed in the Halbouty Geosciences Building. Excellent electron microscopy, surface analysis, and CT-scanning facilities are available in centralized on-campus facilities and maintained by excellent technical staff.
Chapter 3 - Departmental Administration and Management

3.1 Department Head

The Head of the Department of Geology and Geophysics is appointed by and reports to the Dean of the College of Geosciences. On an annual basis, the Department Head is reviewed by the Dean of Geosciences, with input requested from faculty, staff and students.

The appointment of a Department Head is made following a formal search process, with a Search Committee that is appointed by the Dean. The Search Committee is chaired by a head or director of another unit of the college, and Search Committee members consist of faculty from our department. The Search Committee seeks and evaluates applications, and develops a short list of candidates to invite for a series of interviews with the committee and college representatives, and visits with faculty, staff and students. Candidates for Department Head normally give two talks, one that illustrates their research interests, and one on administrative philosophy.

The Search Committee seeks input and calls a vote of the entire membership of the department on short-listed candidates, and ultimately provides a recommendation to the Dean of Geosciences with ranked finalists. At the outset of the search, the Dean determines whether the search is restricted to internal candidates or includes external candidates. The current Head, Andreas Kronenberg, and all prior Heads since the 2002 review (Drs. Hajash, Carlson, and Spang) were internal candidates.

Under university and college policies, heads of departments at Texas A&M University have broad discretionary powers to conduct departmental affairs. Department heads are held responsible for administration of the department, its academic performance, meeting requirements of the department, college, and university, and evaluating faculty and staff for merit raises; in return, department heads receive twelve-month salaries. Since merging the separate departments of geology and geophysics, faculty of the Department of Geology and Geophysics have been directly involved in many decisions, with democratic policies that are reinforced by Vision 2020's imperative of self-governance. The Department Head is regularly advised by faculty and student committees of the Department, and many decisions are made by seeking faculty discussion, consensus, and votes. The Department Head also receives advice from students through the undergraduate Geology and Geophysics Society and the Graduate Student Council. The Department Head and faculty have benefited from meetings and workshops with the Geology and Geophysics Advisory Council (GEODAC), composed of former students and industry recruiters.

A single set of departmental bylaws have not been adopted, but the Department adheres to formal policies at the university, college, and department levels pertaining to faculty and staff hiring.
tenure, promotion, faculty development leaves, adoption of new courses, and policies pertaining to
students, involving curricula, degree requirements, submission of graduate degree plans, and
procedures of M.S. and Ph.D. defenses, and Ph.D. preliminary exams. In addition, policies have
been adopted in the Department to provide faculty input into the distribution of teaching
responsibilities, into recruiting, admitting, and advising students, and awarding student
scholarships and fellowships, into managing shared facilities, and into allocating resources.

With our current policy of shared governance, relatively few decisions are made by the
Department Head without extensive faculty input. Most decisions are made following faculty
discussion of committee recommendations, leading to potential amendments of committee
proposals, and a vote by the faculty (or call for consensus). Implementation of all policies adopted
by the Department is the responsibility of the Department Head.

3.2 Assistant Department Head

An Assistant Head, Dr. Bruce Herbert, has been appointed by the Department Head and approved
by the Dean of Geosciences, with funding for supplementary salary coming from the College of
Geosciences. As requested by the Department Head, the Assistant Department Head serves the
department at times that the Department Head is unavailable, and serves as the department's
Graduate Program Coordinator, chairing the Graduate Recruiting and Admissions Committee.

3.3 Department Meetings and Committees

The Department Head calls faculty meetings about once per month on an as-needed basis during
the academic year, and calls faculty retreats when major planning is needed. The Department
Head chairs these meetings, and graduate student representatives are invited to attend. Faculty
committee organization and appointments of department faculty committees are made by the
Department Head on a rotating basis, with executive committee members serving 3 years and
members of other committees serving 2-year terms. Student committees and leadership positions
are filled by student elections.

Department Faculty Meetings

Department faculty meetings are announced with an agenda and a call is made for additional
topics for discussion. These meetings serve several purposes, including 1) the announcement of
new policies and opportunities offered by the university, college or department, 2) discussion of
new proposals presented by department (or college) committees, 3) discussion of academic
directions, needs, and opportunities, 4) building consensus and identifying areas of differing opinion, and 5) conducting votes on proposed changes to curricula, faculty hiring, and resource allocation.

**Department Executive Committee**
The Executive Committee (*Table 3.1*) consists of faculty representatives of different disciplines and interests of the department; faculty may come from any rank and ideally all faculty ranks should be represented on the Executive Committee. The Executive Committee advises the Department Head on issues involving undergraduate and graduate programs, the department's balance of teaching and research, progress and deficiencies in achieving the department's goals, maintaining priorities, and career development of students, faculty, and staff. Explicit charges of the committee that must be accomplished each year include:

1. an annual review of faculty teaching assignments, and making recommendations of core and introductory course assignments for the coming year.
2. advising the Department Head on annual performance of the department faculty.
3. identifying department members worthy of nomination for awards within the university and offered by professional societies, and recommending faculty for nomination to endowed chairs and professorships.
4. advising the Department Head on distribution of assignments and allocation of resources.
5. reviewing and recommending candidates for departmental postdoctoral fellowships.
6. recommending and evaluating candidates for the Halbouty Visiting Professorship.

<table>
<thead>
<tr>
<th>Table 3.1. Current Executive Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kronenberg (chair)</td>
</tr>
<tr>
<td>Ahr</td>
</tr>
<tr>
<td>J. Chester</td>
</tr>
</tbody>
</table>

**Faculty Search Committees**
With retirements and opportunities to hire faculty in new areas, faculty search committees are formed, with members selected for their specific expertise and related research interests. With the loss of Dr. Hopper, the Dean of Geosciences approved a faculty search for a reflection
seismologist. The Department has advertised for this position and seeks an individual who will help build the department's geophysics program, contribute to the Berg-Hughes Center for Petroleum and Sedimentary Systems, teach seismic interpretation, and collaborate with petroleum geoscientists, stratigraphers, and structural geologists of the department. The current faculty search committee (Table 3.2) consists of geophysics, stratigraphy, and structural geology faculty. As for all search committees, this committee is charged with:

1. defining the search strategy and evaluation criteria.
2. writing and placing advertisements in professional journals.
3. contacting colleagues to learn of outstanding candidates in the area of interest.
4. seeking candidates from underrepresented groups with the goal of diversifying the department's faculty.
5. compiling and evaluating applications.
6. seeking letters of recommendation for selected candidates.
7. recommending a short list of candidates to the Department Head and faculty.
8. scheduling and organizing candidate visits, a department-wide seminar talk, and individual interviews with faculty and students.
9. recommending candidates for a faculty vote.

<table>
<thead>
<tr>
<th>Table 3.2. Seismology Faculty Search Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibson (chair)</td>
</tr>
<tr>
<td>Pope</td>
</tr>
</tbody>
</table>

Tenure and Promotion Committee

The Tenure and Promotion Committee (Table 3.3) plays important roles in the evaluation of long-term progress of junior faculty members towards tenure and promotion, evaluation of non-tenure-track lecturers and research faculty for promotion, and mentoring junior faculty members. The Tenure and Promotion Committee is responsible for making recommendations on tenure and promotion to the Department Head for faculty who have reached the mandatory time of consideration and for faculty members they judge to be ready for early tenure and/or promotion. In addition, the Tenure and Promotion Committee makes recommendations to the faculty and Department Head of faculty applications and nominations for joint, adjunct, and emeritus faculty
appointments. The tenure and promotion committee consists of faculty members who have perspectives across the disciplines of the Department. Most members of the committee are full Professors, but some members have the rank of Associate Professor. Associate Professors are not included in discussion or evaluation of Associate Professors. Specific charges of the Tenure and Promotion Committee include:

1. annual review of the updated TAMU Tenure and Promotion Guidelines provided by the Dean of Faculties.

2. annual review and written evaluation of all tenure-track faculty members of the department who do not have tenure with the university and/or are at the ranks of Assistant or Associate Professor. In those cases where a faculty member is judged ready for tenure and/or promotion, the written evaluation may include a recommendation to seek outside evaluations and that the faculty member be considered for tenure and/or promotion. Annual memoranda of evaluation are provided to the Department Head and individual junior faculty members.

3. annual review and written evaluation of non-tenure-track lecturers and research professors at the assistant and associate ranks. In those cases where a lecturer or research faculty member is considered ready for promotion, the written evaluation may include a recommendation of promotion to the Department Head. Annual memoranda of evaluation are provided to the Department Head and individual junior lecturers or research faculty.

4. written recommendation to the Department Head, for or against tenure and/or promotion. Procedures to consider a faculty member for tenure and/or promotion are a) initiated by the Department Head (at the mandatory time of consideration or by recommendation of the Tenure and Promotion Committee), or b) initiated by request of the faculty member. All teaching, research, service, and professional activities are considered in the evaluation. In addition, the Tenure and Promotion Committee examines and reviews letters provided by outside referees as part of the evaluation, following TAMU Tenure and Promotion Guidelines. The committee’s written recommendation becomes part of the university dossier for consideration of tenure and promotion.

5. review of nominations and/or requests for Adjunct or Joint Faculty appointments with the Department of Geology and Geophysics.

6. review and recommendation of retiring faculty for Emeritus title and privileges, following the University Guidelines on granting Faculty Emeritus Status. The Tenure and Promotion Committee is responsible for making a written recommendation to the faculty and Department Head, which becomes part of the dossier for consideration by the College and Dean of Faculties.
Table 3.3. Tenure and Promotion Committee

<table>
<thead>
<tr>
<th>Everett (chair)</th>
<th>Fox</th>
<th>Raymond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fred Chester</td>
<td>Marcantonio</td>
<td>Zhan</td>
</tr>
</tbody>
</table>

Faculty Mentors

In addition to formal mentoring provided to junior faculty by the Tenure and Promotion Committee, the Department Head arranges for each tenure-track Assistant Professor to have one faculty mentor (or more) for informal discussion and advice. Faculty mentors for current Assistant Professors are given in Table 3.4.

Table 3.4. Faculty Mentors

<table>
<thead>
<tr>
<th>Assistant Professor</th>
<th>Mentor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchun Duan</td>
<td>Fred Chester</td>
</tr>
<tr>
<td>Julie Newman</td>
<td>F Chester/ Raymond</td>
</tr>
<tr>
<td>Michael Tice</td>
<td>Herbert/ Olszewski</td>
</tr>
<tr>
<td>Bridget Wade</td>
<td>Marcantonio/J Chester</td>
</tr>
<tr>
<td>Robert Weiss</td>
<td>Pope/ Raymond</td>
</tr>
</tbody>
</table>

Curriculum Committee

The Curriculum Committee (Table 3.5) provides oversight of the undergraduate programs of the Department, including major degree plans, minors in geology and geophysics, and interdisciplinary programs that involve courses taught by department faculty. The charge of this committee includes:

1. annual review of the department's major degree plans, minors in geology and geophysics and interdisciplinary programs that involve courses of the department.

2. assessment of undergraduate and graduate degree programs, by evaluation of learning outcomes, determining measures of achievement, comparison of findings with achievement targets, and proposing program revisions and improvements to address shortfalls.
3. proposal of changes to undergraduate curricula to the department's faculty, as deemed necessary to improve and/or update the curricula, in response to developments in the Earth sciences, changing career needs, or other opportunities for improvement.

4. development of new curricula, as needed, to meet new career opportunities, and proposal of the new curricula to the department faculty.

5. response to State regulations, University or College policies that require changes to the undergraduate curricula, followed by proposal of these changes to the faculty.

6. proposal of changes to curricula to the college and university curriculum committees.

<table>
<thead>
<tr>
<th>Table 3.5. Curriculum Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sparks (chair)</td>
</tr>
<tr>
<td>Ikelle</td>
</tr>
</tbody>
</table>

**Undergraduate Advisors Committee**

The Undergraduate Advisors Committee *(Table 3.6)* serves the Department and its students through individual advising, through committee discussion of undergraduate student issues and recommendation of students for scholarships. Specific charges of the Undergraduate Advisors Committee include:

1. advising undergraduate students one-on-one.

2. meeting with prospective students and parents of students to inform them of the undergraduate programs, curricula and career opportunities in geology and geophysics.

3. evaluating student performance and making recommendations of students for merit-based scholarships in geology and geophysics.

4. developing and implementing strategies to inform high school students of opportunities in geology and geophysics, and recruit students by way of undergraduate scholarships (when funds become available for undergraduate recruiting).
Table 3.6. Undergraduate Advisors

<table>
<thead>
<tr>
<th></th>
<th>Grossman</th>
<th>B. Miller</th>
<th>Sparks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hajash (chair)</td>
<td>Duan</td>
<td>Heaney</td>
<td>Olszewski</td>
</tr>
<tr>
<td></td>
<td>Giardino</td>
<td>Mathewson</td>
<td>Popp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tennell</td>
</tr>
</tbody>
</table>

Graduate Recruiting and Admissions Committee

The Graduate Recruiting and Admissions Committee is responsible for introducing new and prospective students to the Department's graduate program, making evaluations of prospective student applications for admission, and making recommendations of students for fellowship/scholarship and teaching assistantship support. The committee membership (Table 3.7) includes faculty members who can represent the different disciplines of the department. The specific charges of the committee include:

1. devise and implement graduate student recruiting strategies.
2. arrange for visits of prospective graduate students.
3. initiate correspondence between prospective students and faculty members with common research interests.
4. evaluate incoming applications of prospective graduate students and make recommendations for admission and support through Graduate Teaching Assistantships, Scholarships and/or Fellowships.
5. introduce new graduate students to respective faculty and student research groups. Together with faculty of individual research groups, advise new students in their initial course selections, make arrangements for office space, and keys. Together with the department's IT staff, provide new students with computer and internet access.
6. review the academic performance of current graduate students, and make recommendations for fellowship/scholarship awards, based on nominations and records of academic achievement.
7. make assignments of Graduate Teaching Assistantships, readers and graders, working together with the department's Lab Coordinator to determine teaching needs, schedules, and the student's past performance as a teaching assistant.
Table 3.7. Graduate Recruiting and Admissions Committee

<table>
<thead>
<tr>
<th>Herbert (chair)</th>
<th>Duan</th>
<th>Grossman</th>
<th>Mancini</th>
<th>Newman</th>
<th>Tice</th>
<th>Zhan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahr</td>
<td>Gibson</td>
<td>Hajash</td>
<td>B. Miller</td>
<td>Sun</td>
<td>Weiss</td>
<td>Schorm</td>
</tr>
</tbody>
</table>

Seminar Committee

The Geology and Geophysics Seminar Committee (Table 3.8) serves the Department by planning weekly seminars for each semester of the academic year, inviting seminar speakers, and scheduling speaker visits. Membership on the Seminar Committee includes faculty from a number of disciplines in the department. Seminars are advertised throughout the building, and by way of the department's website.

Table 3.8. Seminar Committee

<table>
<thead>
<tr>
<th>Giardino (chair)</th>
<th>Marcantonio</th>
<th>Tice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hajash</td>
<td>Spang</td>
<td>Wade</td>
</tr>
</tbody>
</table>

Petroleum Geoscience Committee

The Petroleum Geoscience committee (Table 3.9) was formed in 2008 to plan, improve and redevelop the graduate program in petroleum geosciences, in the aftermath of losing two sedimentary geologists who had previously made contributions to the department's applied teaching and research. The committee examined successful geoscience programs at other universities, outlined our current strengths in petroleum geosciences, and proposed means to strengthen the program. One implemented suggestion of this committee is the Petroleum Geosciences Certificate, approved by TAMU's Board of Regents in the summer of 2009. The certificate may be added to M.S. and Ph.D. diplomas signifying broad expertise in energy applications of geology and geophysics. As part of this certificate, members of the Petroleum Geosciences Committee offer an annual Petroleum Geosciences Graduate Seminar. The committee also identifies a faculty advisor for students participating in the annual AAPG Imperial Barrel Competition; last year's Imperial Barrel advisor was Dr. Sun, and this year students will be coached by Dr. Michael Pope.
Table 3.9. Petroleum Geoscience Committee

<table>
<thead>
<tr>
<th>Wiltschko (chair)</th>
<th>Bouma</th>
<th>Ikelle</th>
<th>Spang</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahr</td>
<td>F. Chester</td>
<td>Mancini</td>
<td>Sun</td>
</tr>
<tr>
<td>Blasingame</td>
<td>Gibson</td>
<td>Pope</td>
<td></td>
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</tbody>
</table>

Halbouty Geosciences Building Space Utilization Committee

With recent faculty hires and growing student numbers in the Department of Geology and Geophysics, we have begun to reevaluate our utilization of space. The Space Utilization Committee (Table 3.10) was established to:

1. develop criteria to evaluate utilization of rooms for faculty offices, graduate student offices, teaching laboratories, classrooms, research laboratories, and storage in support of research, teaching, and scholarly activities.
2. identify current use and occupancy of offices, laboratories, classrooms and storage rooms.
3. identify new laboratory, office, classroom needs of current and incoming faculty, staff and students, and the needs for promising new programs.
4. provide assessments of space utilization and recommendations for reallocation of space to Department Head.

Table 3.10. Halbouty Space Utilization Committee

<table>
<thead>
<tr>
<th>F. Chester (chair)</th>
<th>Giardino</th>
<th>Olszewski</th>
<th>Sun</th>
<th>Zhan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everett</td>
<td>Marcantonio</td>
<td>Pope</td>
<td>Wiltschko</td>
<td>Schorm</td>
</tr>
</tbody>
</table>

The Space Utilization committee is assisted by faculty (Dr. Mathewson) and staff members (the department's research specialist, and IT personnel) who provide technical health, safety and infrastructure information.

Computer and IT Committee

The Computer and IT Committee consists of faculty, IT staff, and a student representative (Table 3.11), all of whom are interested in performance of the department's computational facilities, IT network, and website needs. The committee is charged with oversight, upkeep and improvement
of computer and IT facilities, communication and coordination with college web design personnel, and with preparation of proposals to acquire computers, servers, and infrastructure for computer labs and servers.

<table>
<thead>
<tr>
<th>Table 3.11. Computer and IT Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbert (chair)</td>
</tr>
<tr>
<td>Duan</td>
</tr>
<tr>
<td>Everett</td>
</tr>
<tr>
<td>Gibson</td>
</tr>
</tbody>
</table>

**Microprobe Committee**

The Electron Microprobe Facility serves the research needs of a number of department faculty and graduate students, as well as analytical needs of faculty and students from the Colleges of Geosciences, Science, and Engineering. The Microprobe Committee (Table 3.12) is responsible for laboratory oversight, including maintenance costs, deciding on system upgrades, and, ultimately, the preparation of a proposal to acquire a new state-of-the-art electron microprobe to replace the current instrument.

<table>
<thead>
<tr>
<th>Table 3.12. Microprobe Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamb (chair)</td>
</tr>
<tr>
<td>Guillemette (co-chair)</td>
</tr>
</tbody>
</table>

**Microscope Committee**

The Department's Microscope Committee (Table 3.13) is charged with oversight, maintenance, and preparation of proposals for acquisition of optical teaching and research microscope facilities, including microscopes, digital image capture systems, and ancillary computers and image software.
Table 3.13. Microscope Committee

<table>
<thead>
<tr>
<th>Chair</th>
<th>Kronenberg</th>
<th>Pope</th>
<th>Wiltschko</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raymond</td>
<td>Ahr</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lamb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J. Chester</td>
<td>Newman</td>
<td></td>
<td>Wade</td>
</tr>
</tbody>
</table>

Instructional Enhancement/Equipment Fees (IE/EF) Chair

Each semester, proposals for use of funds generated from instructional enhancement/equipment fees are prepared by faculty and submitted to the IE/EF Chair, Dr. Michael Heaney (with the faculty, as a whole, serving on an as-needed selection committee). The IE/EF Chair recommends proposals for funding to the Department Head, based on courses and teaching labs supported by proposed equipment and supply acquisitions or proposed classroom/lab upgrades. Proposals that cannot be funded in a particular cycle are placed on a waiting list and considered for funding the following semester.

Additional Faculty Appointments

Faculty of the Department of Geology and Geophysics serve the department, college, and university in a number of additional functions. Within the Department, Dr. Mathewson maintains and oversees the department's storage facility at TAMU's Riverside campus, where the department's mobile drill rig is stored, along with equipment, furniture, core and sample. Dr. Gibson serves as the department's Library Representative, with oversight of subscriptions, acquisitions and electronic services.

Two representatives of the Department are elected to the college's Geoscience Faculty Advisory Council (GFAC) and a number of faculty serve as representatives on College of Geosciences committees (Table 3.14).


Table 3.14. College Committee Membership

<table>
<thead>
<tr>
<th>Name</th>
<th>Committee</th>
<th>Name</th>
<th>Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. Chester</td>
<td>College GFAC</td>
<td>B. Miller</td>
<td>Geosci. Scholarships Com.</td>
</tr>
<tr>
<td>Marcantonio</td>
<td>College GFAC</td>
<td>Grossman</td>
<td>Geosci. Environment. Prog</td>
</tr>
<tr>
<td>Giardino</td>
<td>Geosci. T&amp;P Committee</td>
<td>Herbert</td>
<td>Geosci. Computer Access</td>
</tr>
<tr>
<td>Raymond</td>
<td>Geosci. T&amp;P Committee</td>
<td>Grossman</td>
<td>Geosci. Safety Committee</td>
</tr>
<tr>
<td>Herbert</td>
<td>Geosci. Curriculum Com.</td>
<td>Gibson</td>
<td>Library Council</td>
</tr>
</tbody>
</table>

3.4 Geology and Geophysics Student Organizations

*Geology and Geophysics Society*

Undergraduate geology and geophysics majors have representation in the Department through the Geology and Geophysics Society with an elected president, vice president and other leadership positions (*Table 3.15*). The society is in charge of modest funds that come from dues, fund raising, and corporate contributions; these funds can be used to support geological field excursions, study breaks and social gatherings. A student lounge is maintained in the Halbouty Geoscience Building and students have secure access to the building at all times throughout the year.

Table 3.15. Geology and Geophysics Society

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travis Johnston</td>
<td>President</td>
</tr>
<tr>
<td>Holly Robinson</td>
<td>Vice President</td>
</tr>
<tr>
<td>Alyssa Franklin</td>
<td>Treasurer</td>
</tr>
<tr>
<td>Drew Hutto</td>
<td>Secretary</td>
</tr>
<tr>
<td>Mikhail Mayzenberg</td>
<td>Field Trips</td>
</tr>
<tr>
<td>Amanda Ulincey</td>
<td>Field Trips</td>
</tr>
<tr>
<td>Courtney Beck</td>
<td>Social Organizer</td>
</tr>
<tr>
<td>Alex Parker</td>
<td>Social Organizer</td>
</tr>
</tbody>
</table>
Graduate Student Council

Graduate students are represented by the Graduate Student Council (Table 3.16), with an elected president, treasurer, secretary, events coordinator, and representatives at the college and university levels. The Graduate Student Council exercises control over Graduate Enhancement funds made available through TAMU student fees for support of educational needs and career development. The Council sends out an annual call to the graduate students of the Department for proposals to attend national meetings and is able to provide partial support of registration and travel expenses for students who make presentations. Graduate Enhancement funds may also be used to support geological field trips.

In addition to university-sponsored student committees, students may join local chapters of the AAPG and SEG. In the case of the AAPG Student Chapter, contributions to AAPG funds by former students and petroleum corporations typically support one or two geological field excursions each year. Chris Beveridge currently serves as interim president of the AAPG Student Chapter, and Stephanie Wood and Regina Dickey serve as the chapter's vice president and secretary, respectively. The SEG Student Chapter hosts student seminars, organized by its leadership (Ibrahim Alhukail and Angelo Ryskov Xavier).

<table>
<thead>
<tr>
<th>Table 3.16. Graduate Student Council</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regina Dickey</td>
</tr>
<tr>
<td>Harold Johnson</td>
</tr>
<tr>
<td><em>open</em></td>
</tr>
<tr>
<td>Clay Bowden</td>
</tr>
<tr>
<td>Cory Redman</td>
</tr>
<tr>
<td>S. Hilding-Kronforst</td>
</tr>
</tbody>
</table>

3.5 Administrative and Technical Services

Administrative Staff

The current office staff consists of a Business Coordinator, a Business Associate, and two Office Associates with student workers hired on a part-time, as-needed basis (Table 3.17). The administrative staff is responsible for processing all administrative, business, and academic matters. The administrative and business activities include processing of employment,
immigration, payroll, purchasing, travel, and management of returned indirect cost funds, IE/EF funds, and funds available through endowments, fellowships, and scholarship funds.

The Department's Business Coordinator, Ms. Sandra Dunham, assists the Department Head by implementing policy, oversight of budgets, and preparing all administrative reports. She is the primary liaison between principal investigators and research administration agencies with the university, and handles State accounts, fellowship/scholarship accounts, gifts, and donations. Business administration involves the use of a number of different university information systems, as well as knowledge of State and university rules and policies, which requires extensive training.

Table 3.17. Geology and Geophysics Administrative Staff in 2009

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandra Dunham</td>
<td>Business Coordinator II</td>
<td>Assists Dept Head, Office Manager supervising staff, responsibility for accounting reports, payroll and donations</td>
</tr>
<tr>
<td>Debra Stark</td>
<td>Business Associate II</td>
<td>Accounts payable, accounts receivable, travel and account reconciliation</td>
</tr>
<tr>
<td>Gwen Tennell</td>
<td>Office Associate</td>
<td>Support of undergraduate programs, rosters and grade sheets, textbook orders, assists Undergraduate Advisors</td>
</tr>
<tr>
<td>Debbie Schorm</td>
<td>Office Associate</td>
<td>Support of graduate programs, class schedules, assists Graduate Program Coordinator</td>
</tr>
<tr>
<td>Page Jones</td>
<td>Student Worker</td>
<td>Answers phone calls, copies, internet searches, errands</td>
</tr>
<tr>
<td>(part-time)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jonathan Strand</td>
<td>Student Worker</td>
<td>Answers phone calls, copies, internet searches, errands</td>
</tr>
<tr>
<td>(part-time)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ellen Skisak</td>
<td>Student Worker</td>
<td>Assists with accounting entries and filing</td>
</tr>
<tr>
<td>(work-study)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The department's Business Associate, Ms. Debra Stark, enters vouchers (accounts payable), reports and implements travel arrangements and reimbursements for faculty, students, and seminar speakers, places all orders over $5,000, and reconciles all purchasing cards for the department.
One of the department's Office Associates, Ms. Gwen Tennell, is the office contact for undergraduate students. She schedules and arranges new student conferences and student registration. Ms. Tennell has access to and reports on student records and performs degree audits for students as they approach graduation. The Department of Geology and Geophysics does not have a staff advisor to undergraduate students, relying instead on faculty to serve as advisors. Students are assigned an advisor by the Undergraduate Advisors Committee Chair, Dr. Hajash. Ms. Tennell orders textbooks for all classes, and handles class rosters, grade reports, and teaching evaluations. She also serves the department's Seminar Committee and posts seminar announcements.

A second Office Associate, Ms. Debbie Schorm is the office contact for the department's graduate students. Ms. Schorm does not advise students, but offers administrative support to the department's Graduate Program Coordinator and the Graduate Recruiting and Admissions Committee. Ms. Schorm maintains all graduate student files, prepares class schedules and assigns classrooms to all lecture and lab courses. She also serves to back up bi-weekly payroll. Ms. Schorm corresponds with corporate recruiters and schedules their visits and interviews for graduate (and undergraduate) students, in coordination with the university's Career Center.

Part-time student workers are hired, either through the university's work-study program or independently, to answer phones and assist visitors to the office. Student workers are asked to distribute mail, photocopy class materials, send faxes, work on files, search the internet for information, run errands, and perform a variety of jobs, as requested. One of our current work-study students has training in Texas A&M System accounting.

We are proud of our department's office staff. The Department of Geology and Geophysics is the largest academic unit of the College of Geosciences, and the numbers of faculty, students and postdocs have grown since 2002, without an increase in staff number. Although the office staff members are experienced and dedicated, they have hit their capacity to fulfill their duties, and support of faculty and student activities is lagging. There is little margin to meet new administrative needs mandated by university policy, or to meet the department's needs during staff leaves for vacation or for health reasons. To meet future needs, we must address staff retention, training, and support. We are concerned about staff retention. Career development of TAMU staff within the department has been difficult; it is generally thought that promotions are more readily achieved by changing academic units. We would like to offer our staff career development training, which will allow reclassification of staff positions and promotion of staff members. Looking to the near future, we will be hard pressed to maintain our academic programs, support new research programs of the Berg-Hughes Center, and assist junior faculty in new research endeavors without hiring additional staff. TAMU staff salaries are low, and it will be very difficult to recruit the capable new staff members that we need.
Technical Staff

Technical needs of the Department are served by four technical (and teaching) support staff (Table 3.18). In addition to these filled positions, the Department recently hired and lost a building proctor. Coordination of introductory Geol 101 and Geol 106 laboratories, and supervision of graduate teaching assistants are provided by the department's Technical Laboratory Coordinator, Dr. Michael Heaney. In addition to these duties, Dr. Heaney teaches two of the department's important field courses, Summer Field Geology (Geol 300) and Introduction to Geologic Field Methods (Geol 309). The department's Associate Research Specialist, Mr. Clayton Powell, provides technical support of the John Handin Rock Deformation Laboratory, and oversees operation, maintenance, and safety of hands-on graduate course laboratories (which are part of Experimental Rock Deformation, Geop 615, and Physics of the Earth's Interior, Geop 660).

Table 3.18. Geology and Geophysics Technical Staff in 2009

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Michael Heaney</td>
<td>Technical Lab Coordinator</td>
<td>coordinates introductory geology laboratories, and field methods teaching responsibilities</td>
</tr>
<tr>
<td>Clayton Powell</td>
<td>Assoc. Research Specialist</td>
<td>support of John Handin Rock Deformation Laboratory, supervises hands-on teaching labs</td>
</tr>
<tr>
<td>Steve Tran</td>
<td>Senior IT Manager</td>
<td>support of departmental computational facilities, network, College and Department servers</td>
</tr>
<tr>
<td>Ryan Young</td>
<td>Microcomputer Specialist</td>
<td>support of microcomputers of faculty, staff, and students</td>
</tr>
<tr>
<td>open</td>
<td>Building Proctor</td>
<td>responsible for health, safety, security, and access to building, maintain inventory, coordinates construction, and implements routine minor maintenance</td>
</tr>
</tbody>
</table>

Adloc's of our information technology (IT) staff have been shifted from the Department of Geology and Geophysics to the College of Geosciences. Nevertheless, offices for IT staff have been retained in the Halbouty Geosciences Building, and day-to-day interactions between IT staff and students and faculty remain strong and effective. Owing to the expertise and positive work spirit of our IT staff, support of the department's computational facilities, network, and servers is excellent. Compared to the private job market for IT professionals, our IT staff is severely underpaid, and so retention and recruitment are always a concern in this area.
A geochemistry technician (Mr. Art Kasson) has been hired recently (Dec. 1, 2009) in support of the new College of Geosciences Stable Isotope Laboratory. A search is currently underway to hire a geochemistry technician for the Ken Williams Radiogenic Isotope Geosciences Laboratory (a College of Geosciences asset housed in our building). The Department recently lost its building proctor, and will need to rehire a capable individual for this position. In the interim, a staff member of the College of Geosciences, Ms. Maureen Reap, has offered to assist the department.

3.6 Financial and Academic Summary

Overview

Department personnel, enrollment and research funding for the last four years are summarized in Table 3.19, from the fall semester of 2006 through the spring semester of 2009. In 2006, the department was just beginning to make its first Faculty Reinvestment and ODASES Program hires; the number of positions increased from 29 to 33 (including the department's Associate Research Professor). Total budgets listed for faculty salary include only the nine-month academic salaries paid by State funds; they do not include salary paid by research grants over the summer, or salary supplements paid to faculty teaching the summer Geology Field course (Geol 300).

As agreed upon with the College of Geosciences administration, additional salary support of up to $20,000 is provided for faculty teaching Geol 300, depending on enrollment, in addition to teaching assistants that are needed to offer this course. With rapidly increasing geology majors in the department, we have been challenged to meet the needs of Geol 300. With a student enrollment of 26 in the summer of 2008, we required two faculty and two teaching assistants to teach this course effectively and safely. Enrollments increased to 31 in summer, 2009, which required two faculty and three teaching assistants. An enrollment of ~44 is anticipated this coming summer, and we will likely need to offer salary for two faculty and four teaching assistants. The Department has received a generous donation from Chevron in support of student Summer Field Scholarships for the upcoming three years, and payment of student field course fees. However, the salary of faculty and students must come from State funds (in excess of allocations listed in Table 3.19).

Faculty salary represents the largest fraction of the Department's budget allocated by State funds; yet, faculty salaries at Texas A&M University are typically lower than of faculty at peer institutions. TAMU's Vision 2020 Report identified fifteen state universities (Table 3.20) that were regarded as peers or target institutions we would like to resemble. Average monthly salaries of faculty in our department are lower than salaries averaged across Texas A&M University, and they are significantly lower, at all ranks, than average faculty salaries of geology and geoscience departments at peer universities (Table 3.21). Monthly salaries in the Department
Table 3.19. Summary of Personnel, Enrollment, and Research Activities 2006-2009

<table>
<thead>
<tr>
<th>PERSONNEL</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty (9 mos)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professors</td>
<td>#</td>
<td>16</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Assoc. Professors</td>
<td>#</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Assist. Professors</td>
<td>#</td>
<td>6</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Lecturers</td>
<td>#</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Research Professors</td>
<td>#</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Budgeted Faculty #</strong></td>
<td>29</td>
<td>32</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td><strong>Faculty Salaries $</strong></td>
<td>2,306,419</td>
<td>2,127,718</td>
<td>2,829,833</td>
<td>2,924,534</td>
</tr>
</tbody>
</table>

| Staff (12 mos) | | | | |
| Administrative/IT | # | 5 | 4 | 5 | 5 |
| Research | # | 4 | 4 | 5 | 5 |
| **Total Budgeted Staff #** | 9 | 8 | 10 | 10 |
| **Staff Salaries $** | 294,747 | 276,641 | 291,028 | 249,374 |

| Graduate Assistants | | | | |
| Teaching GAT (9 mos) | # | 39 | 38 | 41 | 47 |
| Research GAR (9 mos) | # | 14 | 15 | 17 | 17 |
| Research GAR (12 mos) | # | 3 | 3 | 3 | 2 |
| **Total Grad Assistants #** | 56 | 56 | 61 | 66 |
| **Total Teaching Assist Budget $** | 246,693 | 233,381 | 267,089 | 290,511 |

<table>
<thead>
<tr>
<th>ACADEMICS</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>#</td>
<td>112/132</td>
<td>126/157</td>
<td>161/185</td>
</tr>
<tr>
<td>Graduate M.S.</td>
<td>#</td>
<td>44/43</td>
<td>39/43</td>
<td>43/56</td>
</tr>
<tr>
<td>Graduate Ph.D.</td>
<td>#</td>
<td>39/37</td>
<td>39/33</td>
<td>29/27</td>
</tr>
<tr>
<td><strong>Total Students #</strong></td>
<td>213 (avg)</td>
<td>220 (avg)</td>
<td>246 (avg)</td>
<td>287 (avg)</td>
</tr>
<tr>
<td>Student Credit Hours (SCH)</td>
<td>#</td>
<td>15,185</td>
<td>14,803</td>
<td>16,832</td>
</tr>
<tr>
<td>Weighted SCHs (WSCH)</td>
<td>#</td>
<td>46,139</td>
<td>44,588</td>
<td>48,995</td>
</tr>
<tr>
<td>UG Courses</td>
<td>#</td>
<td>25</td>
<td>25</td>
<td>27</td>
</tr>
<tr>
<td>UG Sections</td>
<td>#</td>
<td>385</td>
<td>406</td>
<td>448</td>
</tr>
<tr>
<td>Enrollment</td>
<td>#</td>
<td>3469</td>
<td>3460</td>
<td>3947</td>
</tr>
<tr>
<td><strong>GAT Avg. Stipend (M.S.)</strong></td>
<td>$</td>
<td>1400</td>
<td>1400</td>
<td>1647</td>
</tr>
<tr>
<td><strong>GAT Stipend (Ph.D. pre-qual)</strong></td>
<td>$</td>
<td>1600</td>
<td>1600</td>
<td>1867</td>
</tr>
<tr>
<td><strong>GAT Stipend (Ph.D. post-qual)</strong></td>
<td>$</td>
<td>1700</td>
<td>1700</td>
<td>1976</td>
</tr>
</tbody>
</table>
of Geology and Geophysics fall below those at peer institution departments by 20%, 11%, and 11% for Professors, Associate Professors, and Assistant Professors, respectively. While Texas A&M salaries are generally slightly lower than peer institutions, that discrepancy is largest in the College of Geosciences, and has doubled in the last four years (based on TAMU Office of Institutional Studies Report). The Geology and Geophysics current overall deficit of 16% is the second largest of the 60 departments in the University. This is troubling given that the department’s ranking (22nd of departments at State Universities; U.S. News and World Report, 2006) is comparable to Texas A&M's overall ranking (22nd of departments at public universities; U.S. News and World Report, Dec. 1, 2009). The Department lost four faculty members to competitive offers in the last four years, two to the petroleum industry, one to a four-year college and one to a geological survey. We also lost a number of outstanding faculty prospects to other universities. Start-up funds were implicated in the loss of prospective faculty to other universities but better faculty salaries have been important as well.

The number of staff positions in the department has not changed much (Table 3.19). Consequently, total budgets for staff salary have not changed substantially. Graduate teaching assistant (GAT) funding for the departments of the College of Geosciences are allocated according to the number of laboratory sections and students taught. Owing to the substantial numbers of introductory core science courses offered by our department, and the growth in our undergraduate student enrollments, we are able to support a significant number of graduate
students through teaching assistantships (GATs, *Table 3.19*). Based on recommendations of our 2002 External Review, we have made attempts to increase monthly salaries of teaching assistantships, and recommended similar increases to PIs who support research assistantships. In addition, the university initiated the current policy of paying graduate tuition and benefits for teaching and research assistants (paid by the state for GATs and by research grants for GARs). The current monthly stipends of $1647, $1867, and $1976, respectively, for M.S. candidates, and Ph.D. candidates before and after passing their qualifying exams are adequate in many cases, but our experience recruiting the most competitive Ph.D. candidates to our graduate program has been disappointing.

**Table 3.20. TAMU - State Peer Institutions U.S. News and World Report Rankings**

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas A&amp;M</td>
<td>24</td>
<td>27</td>
<td>22</td>
<td>21</td>
<td>21</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Univ Texas</td>
<td>14</td>
<td>17</td>
<td>14</td>
<td>17</td>
<td>13</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>UC Berkeley</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Univ Michigan</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>North Carolina</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>UCLA</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>UC San Diego</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Univ Wisconsin</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Univ Florida</td>
<td>17</td>
<td>15</td>
<td>16</td>
<td>16</td>
<td>13</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Georgia Tech</td>
<td>9</td>
<td>9</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Univ Illinois</td>
<td>9</td>
<td>10</td>
<td>9</td>
<td>11</td>
<td>10</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Univ Minnesota</td>
<td>20</td>
<td>22</td>
<td>26</td>
<td>30</td>
<td>27</td>
<td>29</td>
<td>22</td>
</tr>
<tr>
<td>Ohio State</td>
<td>24</td>
<td>22</td>
<td>22</td>
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<tr>
<td>Penn State</td>
<td>12</td>
<td>15</td>
<td>16</td>
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<tr>
<td>Purdue Univ</td>
<td>20</td>
<td>20</td>
<td>22</td>
<td>21</td>
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<td>24</td>
<td>26</td>
</tr>
<tr>
<td>UC Davis</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>14</td>
<td>13</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>
Table 3.21. Faculty Salaries TAMU Geology and Geophysics and Peer University Departments 2009

<table>
<thead>
<tr>
<th></th>
<th>Mean Monthly Salaries</th>
<th>G&amp;G - Peer Geosci.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TAMU (Mean)</td>
<td>TAMU Geol &amp; Geop</td>
</tr>
<tr>
<td>Professor</td>
<td>$12,989</td>
<td>$11,172</td>
</tr>
<tr>
<td>Assoc Professor</td>
<td>$9098</td>
<td>$8,697</td>
</tr>
<tr>
<td>Assist Professor</td>
<td>$8093</td>
<td>$7,065</td>
</tr>
</tbody>
</table>

The number of funded research projects in the Department of Geology and Geophysics has grown substantially from 2006 to the present (Table 3.19). In 2006, department faculty were principal investigators (PIs) of 16 and 17 projects administered, respectively, by the university's Research Foundation (TAMRF) and the Texas Engineering Experiment Station (TEES). In 2009, faculty were PIs of 48, 17, and 2 projects, respectively, administered by TAMRF, TEES, and TAMU Research Services (TAMU-RS). Summing over active research grants and contracts in the department, total research funding has grown 73% from $3.32M in 2006 to $5.77M in 2009 (Table 3.19 and Figure 3.1).

Most of these grants are multi-year research projects, and only a fraction of indirect costs of each grant is returned to the department. Annual research expenditures (including annual direct costs only) reported for the department by TAMRF, TAMU-RS, and TEES have more than doubled (factor of 2.5) from $703,900 for fiscal year 2004-2005 (FY05) to $1,768,000 (Figure 3.1) for fiscal year 2008-2009 (FY09). A significant fraction of 2008-2009 expenditures corresponds to a NSF MRI grant of $444,400 to acquire scientific instrumentation. However, expenditures in 2004-2005 also included an instrument acquisition of $217,200. If equipment expenditures are deducted, research expenditures from FY05 to FY09 are up by a factor of 2.7. While annual research expenditures of geology and geophysics faculty projects serviced by TEES have increased significantly from FY05 to FY09, the indirect returns from TEES projects to the College of Geosciences has not grown in proportion to direct research expenditures due to differences in indirect cost treatment of TEES projects.

The Department's average annual research funding per faculty member has grown steadily but is still not as large as per capita funding in the College's Departments of Atmospheric Sciences or Oceanography. Research funding of our faculty varies according to demographics and discipline; recently hired, junior faculty have excellent per capita funding rates. Although the Department of Geology and Geophysics does not rank highest amongst departments of the
College of Geosciences in terms of returned indirect costs, we rank at the top in enrolled majors, and we continue to maintain heavy teaching loads while progressively expanding our research program.

![Graph showing funded research and annual expenditures](image)

**Figure 3.1. Total Research Funds for Calendar Years 2006 to 2009, and Annual Expenditures (including TAMRF, TAMU-RS, and TEES) for Department of Geology and Geophysics in Fiscal Years 2004-2005 to 2008-2009**

**Operations Budget**

Operational funds for the College of Geosciences are allocated to departments according to a formula that depends equally on 1) department size and teaching load, and 2) returned indirect funds, which are meant to measure research activity. Based upon the relatively modest indirect funds coming to the College from Department of Geology and Geophysics grants, our operational funds have not covered routine departmental expenses for the last four years. As the largest department of the College, operational funds (of ~$156,000) have typically been depleted by late March, whereupon we have needed to pay for office supplies, phones, and photocopying from discretional department monies that would otherwise have gone to lab upgrades, building repairs, replacing aging classroom and office furniture, sending students to meetings, and building up funds for prospective faculty start-up.
Research Funding and Administration

The Department currently has a diverse number of funded research projects (Appendix E) and unfunded studies that may lead to funded research. The majority of Geology and Geophysics faculty submit research proposals through the Texas A&M Research Foundation (TAMRF). The Research Foundation is a non-profit corporation created in 1944 specifically to manage externally-funded research at TAMU. However, the university has multiple agencies and offices that administer research grants and contracts. When Geology and Geophysics faculty submit collaborative proposals with co-PIs from the College of Engineering, projects are commonly administered by the Texas Engineering Experiment Station (TEES) or the Texas Transportation Institute (TTI). Texas A&M University also has an internal Office of Research Services (TAMU-RS). This office generally manages grant and contract funds from the State of Texas and other sources that pay less than the standard university indirect cost rate of 46.5%.

Because of the variety of funding sources and collaborations by G&G faculty, the Department ultimately deals with all four project management offices. This places a burden on office staff because the different project management offices have their own unique policies and procedures and each uses different accounting software. Attempts to consolidate research administration at the Texas A&M University System level have met with strong resistance from various groups accustomed to dealing with their local agency or office. Within Geology and Geophysics, researchers tend to prefer to work with the TAMU Research Foundation because of their higher level of services, both at the stage of proposal preparation and during project administration. TEES offers excellent services for grants and contracts held with engineering faculty co-PIs.

All of the research management agencies at Texas A&M University pass portions of the generated indirect cost funds to the colleges. Within the College of Geosciences, the funds received from TAMRF grants are divided so that $2/7$ are retained at the college level and $5/7$ are passed to the departments. This is calculated in proportion to the funds generated by each department. The Department of Geology and Geophysics awards a 50/50 split of returned indirect cost funds between the department and individual PIs. Indirect cost return formulas of the Research Foundation have changed in recent years to reflect a percentage of direct costs rather than percentage of indirect costs. This has caused problems for educational and equipment acquisition projects that do not generate significant indirect costs. The university is in the process of evaluating grant processing costs and overhead distributions in order to devise an equitable system for these types of grants. At issue are proposals for educational studies and acquisition of state-of-the-art instrumentation.

Over the eight-year period since our last External Review, the department has hired and lost a significant number of faculty members. The junior faculty we hired are very ambitious and vigorously seek extramural funding for their research. Their needs for state-of-the-art
laboratories and facilities are correspondingly larger than start-up packages offered to incoming faculty eight years ago. Start-up funds made available by the University to colleges and departments for faculty hires under the Reinvestment Program made it possible for the Department to make a number of competitive faculty offers. Nevertheless, some college and departmental funds were required in all faculty hires, drawing on local resources.

Now that the Faculty Reinvestment Program has been completed, we are challenged to accumulate sufficient funds from returned indirect funds to make competitive faculty offers to young research scientists who have promise to raise our research productivity and stature. This problem is exacerbated by the recent losses of young productive faculty (e.g., Drs. Hopper and McGuire) who left our department just as they were awarded tenure. We do not expect that start-up needs of the next faculty hires will be identical to those of faculty who recently left the department. Thus, offering attractive start-up packages to new faculty candidates will be difficult. Faculty salary savings to the College of Geosciences budget should help build college funds needed to make competitive start-up offers, supplementing funds generated by return on indirect costs. However, without retaining some fraction of faculty salary savings in the Department, funds available for the department to supply its match to competitive start-up offers will be depleted with only a few new hires.

**Educational Resources**

The faculty and students of the Department of Geology and Geophysics benefit from a number of university programs that offer education resources. Instructional Enhancement/Equipment Fees (IE/EF) paid by TAMU students provide funding each semester to improve our classrooms and teaching laboratories. These funds have been used to improve teaching collections, acquire and repair microscopes, purchase portable GPS units and geophysical field equipment, purchase laboratory supplies, and purchase and replace projectors and screens. The department submits proposals annually to the university's Classroom Instructional Technology (CIT) program, which helps improve computer labs, and audio-visual-computer facilities of classrooms. Faculty have access to the Faculty Workstation Program, which is intended to fund the replacement of faculty workstations once every four years (though in recent years, funds available to the department are sufficient to replace workstations only once every five years dependably).

Students and faculty of the Department are fortunate to have excellent relations with former students and corporations in the energy industry. Generous contributions by former students and petroleum companies provide 1) support of students through scholarships and fellowships, 2) support of faculty through endowed Chairs and Professorships, and 3) support of departmental operations through unrestricted discretionary funds. In recent years, the Department has received unrestricted contributions from ExxonMobil, ION Geophysical, Hess, Marathon, and Anadarko. The Geology and Geophysics Seminar has been funded annually by ConocoPhillips. Student
scholarships and fellowships are described in Chapters 5 and 6 on undergraduate and graduate programs, respectively. Faculty endowments contribute resources to a wide range of departmental functions, and are described in this chapter.

3.7 Faculty Endowments

The Department of Geology and Geophysics has strong support from its former students, with a number of generous donations made in support of named faculty endowments in the department and college. A number of current faculty members enjoy the benefits of holding a named chair or professorship (Table 3.22). Endowed chairs provide annual earnings of $50,000 and endowed professorships provide yearly earnings of $10,000, which can be used for a variety of scholarly purposes, including support of research, students, and postdocs. Faculty Chairs may also use earnings for one month of summer salary each year, compensating for recent NSF restrictions on faculty salary support.

Table 3.22. Endowed Chairs and Professorships held by Geology and Geophysics Faculty in 2009

<table>
<thead>
<tr>
<th>Faculty Name</th>
<th>Named Chair or Professorship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richard Carlson</td>
<td>Dudley J. Hughes Chair in Geology and Geophysics</td>
</tr>
<tr>
<td>Fred Chester</td>
<td>David Bullock Harris Chair in Geology</td>
</tr>
<tr>
<td>Ethan Grossman</td>
<td>Michel T. Halbouty Chair in Geology</td>
</tr>
<tr>
<td>Ernest Mancini nominated</td>
<td>Dan A. Hughes Chair in Geosciences</td>
</tr>
<tr>
<td>David Wiltschko</td>
<td>Michel T. Halbouty Chair in Geology</td>
</tr>
<tr>
<td>Mark Everett</td>
<td>Howard Karren Professorship in Geology and Geophysics</td>
</tr>
<tr>
<td>Richard Gibson</td>
<td>Francesco Paolo di Gangi/Heep Professor Theoret. Geophysics</td>
</tr>
<tr>
<td>Bruce Herbert</td>
<td>EOG Teaching Professorship in Geosciences</td>
</tr>
<tr>
<td>Luc Ikelle</td>
<td>Robert R. Berg Professorship in Geology and Geophysics</td>
</tr>
<tr>
<td>Hongbin Zhan</td>
<td>Ray C. Fish Professorship in geology</td>
</tr>
<tr>
<td>open</td>
<td>Williford Professorship in Petroleum Geology</td>
</tr>
</tbody>
</table>
Chairs and professorships may be awarded to new, incoming faculty with the purpose of recruiting outstanding individuals to the department. Alternatively, faculty of the department with outstanding research and teaching records may be honored through the award of an endowed chair or professorship. Nominations of candidates for chairs and professors are submitted to the College of Geosciences, which appoints a selection committee made up of Distinguished Professors of the College, and a faculty representative from each department of the College of Geosciences. The Chairs and Professorships Selection Committee is chaired by the dean of another college at TAMU. Chairs are awarded for a five-year period and professorships are awarded for a three-year period, with possible renewals for an additional term. Depending on the donor's letter of intent, any given chair or professorship may be restricted to individuals from a specific department or faculty with scholarly achievements in a specific research area. Faculty from the Department of Geology and Geophysics are eligible for a number of college chairs and professorships. In addition they are eligible for departmental chairs and professorships.

The department has benefited in recent years from the generosity of Dr. Andy Hajash who, as the Harris Chair in Geology, made funds available for postdoctoral fellows who worked with any faculty of the department. As endowment earnings became available, announcements were made nationally for applications to a two-year Harris Postdoctoral Fellowship. Applications were evaluated on a competitive basis, by a departmental selection committee that judged academic and professional merit, and potential for collaboration with faculty of the department.

The Department has a unique resource, the Halbouty Visiting Professorship, which is used to bring outstanding scientists to Texas A&M for a sabbatical visit. Halbouty Visiting Professors are expected to give an invited talk, and they may give an extended series of seminars or workshops. We also encourage Halbouty Visiting Professors to collaborate with faculty and students of the department. The most recent recipient of the Halbouty Visiting Professorship, Dr. Renee Heilbronner of Basel University, visited for a semester, and followed up her first visit with a second, collaborative research visit. Dr. Heilbronner gave a week-long workshop on microstructural analysis, which drew students and researchers from across the United States. In addition, she brought three Ph.D. students with her from Basel University for scientific exchange and research collaboration with our students and faculty.

3.8 Facilities

In our 2002 External Review, the Halbouty Geosciences Building and its teaching facilities were judged to be excellent. The Department's research facilities were considered excellent in a few research areas and adequate in a wide range of fields. It was recommended that we improve our
analytical capabilities through acquisition of state-of-the-art instrumentation and consider building shared facilities rather than invest in many single-PI laboratories. Significant developments have allowed us to follow this advice, and we have built new environmental geology and geobiology laboratories, and state-of-the-art geochemistry laboratories, which are College of Geosciences facilities that enable radiogenic and stable isotopic studies by faculty and students of three departments. Faculty and students of the Department of Geology and Geophysics have access to research laboratories and facilities within the department, college, and university. Many of our laboratories are run as shared facilities, with access limited only by safety considerations and training in lab practice and competent use of sensitive instrumentation.

The Halbouty Geosciences Building, is one of the older buildings on campus (constructed as part of the Agricultural and Mechanical College of Texas in 1932). A new wing added in 1984 resulted in its current size of 7060 square meters. Classrooms of all sizes are available for courses from the 180-student-capacity Dudley Hughes Lecture Hall to small, graduate seminar rooms. We have a large number of teaching laboratory rooms; yet, owing to the large numbers of Geol 101 lab sections we offer, these lab rooms are in use throughout each available hour of the week.

Most classrooms now offer modern instructional technology, thanks to CIT and IE/EF funds, including digital projectors, computers and/or computer hookups, and internet access. A building security system has recently been installed with faculty, student, and staff access during evenings and weekends provided by ID card readers. The building's roof has recently been sealed and its exterior is scheduled for maintenance during the upcoming year.

Despite these improvements, classrooms and teaching labs suffer from deferred building maintenance and lack of funds to replace aging furniture. Frequent plumbing failures have threatened computers and laboratory instrumentation, and poor temperature regulation has led to excessive energy usage and unpleasant conditions in classrooms, labs, and offices. Significant settling problems have been experienced under the original wing of the building and surrounding it. Both the built-in seats of our large capacity lecture hall and chairs of classrooms and labs date to 1984 and are in need of replacement. Many of the research laboratories are also used for instructional purposes and graduate laboratories. We describe research laboratories of the department and their application in courses in Chapter 7 (section 7.3).
Chapter 4 - Centers and Affiliations

The Department of Geology and Geophysics at Texas A&M University benefits from faculty and student affiliation with research centers and departments in the College of Geosciences. The Department currently has eight joint professors and ten adjunct professors who occasionally teach courses in our department, offer related courses in other departments, and serve on graduate student research committees. Research collaborations between adjunct and joint faculty with FTE faculty contribute to innovation and collaboration across disciplinary boundaries. Four adjunct faculty in Geology and Geophysics are Ph.D. scientists in the Integrated Ocean Drilling Program (IODP). Two faculty in our department are members of the ODASES Program (one adloc in Geology and Geophysics and one joint with Oceanography). Four faculty have joint appointments with our department and the Department of Oceanography (one adloc with Geology and Geophysics). Two professors have joint appointments with our department and the Department of Geography (one adloc with Geology and Geophysics). The Department of Geology and Geophysics has an adjunct professor from the Department of Petroleum Engineering and we share two joint professors (one adloc in Geology and Geophysics) with Petroleum Engineering.

The Dean of Geosciences, Professor Kate Miller, has her academic home with our department as does the Director of the IODP, Professor Brad Clement. A significant number of faculty members are associates of the Center for Tectonophysics and many faculty have expressed interest in the newly formed Berg-Hughes Center for Petroleum and Sedimentary Systems. Some faculty in our department teach courses of the College’s Environmental Studies Program, and others serve as advisors and graduate research committee members of students in the university's Water Management and Hydrological Sciences Program.

The Department of Geology and Geophysics has traditional strengths in petroleum geosciences, and we have benefited from an active and supportive advisory council. Texas A&M geology and geophysics students are in high demand in the energy industry, and recruiters come to our department each year from major oil and gas companies and many smaller producers involved in geological and geophysical exploration.

4.1 Center for Tectonophysics

The Center for Tectonophysics (http://geoweb.tamu.edu/tectono/) was established in 1967 to 1) carry out an integrated program of theoretical, experimental, and field research in rock deformation, 2) educate graduate students in geomechanics, physical properties of Earth materials, structural geology and experimental geophysics, and 3) support graduate instruction in
other units of the College of Geosciences as well in allied fields of petroleum, mechanical and civil engineering. The Center is a research group, not a degree-granting entity of the University. Affiliation with the Center by faculty, research scientists, and graduate students is voluntary. Faculty affiliation is defined by collaboration in research, writing proposals for funding and laboratory development, teaching the Center core-courses, and advising Center graduate students. Currently, seven faculty associates from the Department of Geology & Geophysics are fully engaged in all the Center activities of teaching, advising, grant writing, and research. A similar number of additional faculty members, from both within and outside the Department of Geology & Geophysics participate in a subset of these activities. In addition to faculty associates, the professional staff includes two postdoctoral scientists, and an Associate Research Specialist who supports laboratory activities, both for research and teaching. Faculty associates elect on a rotating basis, one member to serve as the Director of the Center; Dr. Fred Chester has led the Center since fall, 2006. Although the faculty affiliated with the Center has changed over the years, the associates have maintained a strong research focus and esprit de corps.

Graduate students of the Center 1) enroll in one of the teaching departments of the University (this is typically, but not exclusively, the Department of Geology and Geophysics) 2) specialize in research that is within the scope of the staff and laboratory facilities of the Center, 3) have an advisory committee chair that is a member of the Center faculty, and 4) establish a degree program that includes four core courses and one seminar of the Center core curriculum. Currently, there are 17 Center students, who are advised by 5 of the faculty members affiliated with the Center for Tectonophysics.

The Center core curriculum is designed to provide students with a solid foundation in theoretical mechanics, an understanding of the fundamental mechanisms of deformation, the characterization of physicochemical and mechanical properties of rock, and the observation and integrated analysis of natural processes. In addition, the coursework provides laboratory experience in numerical modeling, microstructural and chemical analysis, and experimental rock deformation using the Center’s unique laboratory facilities. In addition, course activities help develop skills such as critical thinking and communication that are necessary for professional success. A number of Center students continue in academia and other avenues of research upon graduation though the majority of the students seek employment in the energy industry.

4.2 Berg-Hughes Center for Petroleum and Sedimentary Systems

As part of the Department's initiative to rebuild graduate programs in petroleum geosciences and sedimentary geology, a new research center has been established in the College of Geosciences that will facilitate interdisciplinary approaches in geology, geophysics, and petroleum
engineering. The Berg-Hughes Center (http://berg-hughes.tamu.edu/) was approved by the TAMU Board of Regents in July, 2009, and initial fund raising quickly provided $2.9M in endowments. The Berg-Hughes Center owes its name to 1) Dr. Robert R. Berg, who was an admired faculty member of the department and member of the National Academy of Engineering, and 2) the Hughes family, three of whom are graduates of Texas A&M University and successful, independent oil and gas entrepreneurs. Earnings from the Dan A. Hughes ’51 Chair in Geosciences will support the academic activities of the Director of the Berg-Hughes Center, and funds from remaining endowments will largely go to students through scholarships, graduate fellowships, and undergraduate summer internships.

The Berg-Hughes Center brings together faculty researchers who may be separated by traditional departmental and college boundaries, and scientists and engineers employed in the energy industry. The center will promote education and publicly and privately-funded research that focuses on applications of sedimentology, stratigraphy, petroleum engineering, and geophysics to petroleum reservoir exploration, imaging and characterization. The center will educate a new generation of petroleum and sedimentary geoscientists capable of meeting the nation's energy challenges.

Dr. Ernest Mancini will assume the position of Director of the Berg-Hughes Center and join the Department of Geology and Geophysics, in the spring semester, 2010. Formerly at the University of Alabama, Dr. Mancini has an outstanding record of leadership and high-visibility research in petroleum geoscience along with a history of outstanding research support. As the former Director of the Center for Sedimentary Basin Studies at the University of Alabama, he is a Distinguished Professor of Petroleum Geology and Stratigraphy and a nominee for President of the AAPG. Dr. Mancini has a remarkable record of success in building programs and has generated $10 M in research funding at the University of Alabama over the last 12 years.

4.3 Integrated Ocean Drilling Program

Faculty and students of the department benefit from research interactions with research scientists of the Integrated Ocean Drilling Program (IODP). The United States Implementing Organization (IODP-USIO) is responsible for the scientific operations of the dynamically positioned, riserless drilling vessel, JOIDES Resolution (http://iodp.tamu.edu/publicinfo/drillship.html), archiving the scientific data and samples that are collected, and producing and disseminating program publications. The goal of the program is to recover the record of Earth’s history that is written in the rocks and sediments of the ocean floor. These scientific samples and data are used to study, for example, plate tectonics, ocean currents, climate changes, evolutionary characteristics and extinctions of marine life, and mineral deposits.
The IODP Director, Dr. Brad Clement is a Professor in the Department of Geology and Geophysics and many IODP research scientists have adjunct appointments in the Department. In addition, Texas A&M University initiated the Ocean Drilling and Sustainable Earth Science (ODASES) Program as an interdisciplinary, multi-college research and education effort, in order to enhance faculty participation in IODP. Led and directed by The College of Geosciences, ODASES sponsors laboratory facilities, including a recently-installed XRF core scanner, as part of the Gulf Coast Repository. ODASES faculty in Geology and Geophysics include Drs. P.J. Fox, E. Grossman, B. Wade, and D. Thomas (a joint faculty member with Oceanography). IODP scientists with adjunct faculty appointments in Geology and Geophysics include Drs. Firth, Geldmacher, Malone, and J. Miller.

4.4 Geochemical and Environmental Research Group

Faculty and students have the opportunity to collaborate with research scientists of the Geochemical and Environmental Research Group (GERG) of the College of Geosciences, a soft-money research lab that addresses applied problems in petroleum and environmental research ([http://gerg.tamu.edu/](http://gerg.tamu.edu/)). GERG employs two dozen scientists, managers and technical staff with expertise in geochemistry, oceanography, atmospheric sciences, and environmental and analytical chemistry. GERG hosts extensive organic geochemistry laboratory facilities, with four high performance liquid chromatographs, ten gas chromatographs, and five gas chromatograph/mass spectrometers. Environmental geosciences faculty and students of the Department have recently collaborated with GERG scientists on organic biomarker research.

4.5 Department of Oceanography

Three faculty members of the Department of Oceanography ([http://ocean.tamu.edu/](http://ocean.tamu.edu/)), Drs. Richardson, Sager, and Thomas have joint appointments in the Department of Geology and Geophysics. In addition, Dr. Fox, whose primary affiliation is with our department, holds a joint appointment in Oceanography.

Faculty members from Oceanography and Geology and Geophysics co-teach some classes that are taken by students from both departments, and serve on graduate committees for students in either department. Because geological oceanography students often have undergraduate degrees in geology, these students can serve as teaching assistants (GATs) in our introductory courses. Research areas of greatest interaction between the departments include paleoclimate, geochemistry, paleoceanography, seismic exploration, geodynamics, and micropaleontology. Stable isotope geochemistry laboratories of Geology and Geophysics and Oceanography have
recently been merged, and faculty from both departments share the College's new radiogenic isotope geochemistry laboratory.

4.6 Department of Geography

Two faculty members, Drs. R. Giardino and V. Tchakerian, with interests in geomorphology have joint appointments in Departments of Geology and Geophysics, and Geography (http://geography.tamu.edu/). Dr. Giardino has his administrative location in our department, while Dr. Tchakerian has his adloc in Geography. The department's course in GPS (Geol 352) has become so popular with Geography students that Geography faculty (Dr. Houser) have taught this course and it will soon become cross-listed as Geog 352. Faculty from Geography have been members of graduate research committees of our students. The Geography Department is currently undergoing a search for a new Department Head, and a member of our department, Dr. J. Chester, serves on this committee. Facilities between the two departments are also shared, particularly with the new Stable Isotopes Laboratory, which is directed by Dr. Roark of Geography.

4.7 Water Management and Hydrological Sciences Program

Several faculty members of the department, Drs. Giardino, Herbert, Mathewson, and Zhan, conduct research and advise students as part of the University's Water Management and Hydrological Sciences Program (http://waterprogram.tamu.edu/). Both Drs. Giardino and Zhan serve on the water program's Executive Committee, and Drs. Herbert and Mathewson are Associate Members of the Program. Dr. Zhan is the advisor of the student organization "Water without Boundaries." Geology and Geophysics offers several key courses of the water program, including Hydrogeology (Geol 410), Applied Ground Water Modeling (Geol 625), Contaminant Hydrogeology (Geol 621), and Environmental Geochemistry (Geol 641). Geology and Geophysics faculty serve as Chairs of Research Advisory Committees of about ten graduate students in this program.

4.8 Industrial Partnerships

The Department of Geology and Geophysics at Texas A&M is committed to establishing and maintaining strong ties with industry. The ongoing cooperation, collaboration and communication with industry benefits the research endeavors of the Department and our industry partners. Traditionally, the goals of universities (reputation for quality education and published
research) differ from those of the energy industry (profitable endeavors of exploration and production, refining, and supply) (Figure 4.1). However, our ability to achieve our goals depends on the quality of students, our ideas, and the development and application of methods, much as the ability of a company to succeed depends on its people, ideas, and tools.

Figure 4.1. Mutual Benefits of University-Industry Partnerships with Petroleum Companies.

The Department has benefited from interactions with the department's Geology and Geophysics Advisory Council, from technical seminars offered by industry experts, and from on-campus industry recruiting for jobs and internships. Our students have benefited through undergraduate scholarships, graduate scholarships and fellowships, industry support of field courses, support of the department's seminar, and industry-university research collaborations.

Geology and Geophysics Advisory Council

The Department is fortunate to have the advice and support of the Geology and Geophysics Advisory Council (GEODAC). The council is made up of former students and representatives of potential student employers (Table 4.1). Membership of GEODAC is determined by nomination and election and based on leadership in energy and environmental industries, academia and professional societies. Members serve for one to two three-year terms. The stated goal of GEODAC is to help the Department "build a geoscience community of students, staff, and faculty who excel through collaborative pursuit in teaching and research."

In each of the last three years we have met with GEODAC in regular meetings held twice a year and extra meetings called as needed. Strategic planning workshops with GEODAC led to 1) development and adoption of a set of core values, 2) focused evaluation and development of our
Table 4.1. Geology and Geophysics Advisory Council 2009

<table>
<thead>
<tr>
<th>Members</th>
<th>Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. William Barkhouse</td>
<td>Michael Lilly</td>
</tr>
<tr>
<td>ABC-GEO, Inc.</td>
<td>President, Geo-Watersheds Scientific</td>
</tr>
<tr>
<td>Diane Barron</td>
<td>Grant MacRae</td>
</tr>
<tr>
<td>Texas A&amp;M University</td>
<td>GXT Imaging Solutions</td>
</tr>
<tr>
<td>Dr. Lee Billingsley (Chair)</td>
<td>Dustin Marshall</td>
</tr>
<tr>
<td>Abraxas Petroleum Corp.</td>
<td>VP, Amerada Hess Corp</td>
</tr>
<tr>
<td>Kellam Colquitt</td>
<td>Ron McWhorter</td>
</tr>
<tr>
<td>Reef Exploration Co. (recently retired)</td>
<td>Devon Energy Corp</td>
</tr>
<tr>
<td>Dr. Carlos Dengo</td>
<td>Dan Pedrotti</td>
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<tr>
<td>VP, ExxonMobil Upstream Research Co.</td>
<td>SueMar Exploration, Inc.</td>
</tr>
<tr>
<td>Dr. Terry Engelder</td>
<td>Andreas Kronenberg</td>
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<td>Penn State University</td>
<td>Texas A&amp;M University</td>
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<td>Walter Hufford</td>
<td>Dr. Carl Steffensen</td>
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<tr>
<td>Environmental Manager</td>
<td>BP America, Inc.</td>
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<tr>
<td>Atlantic Richfield Co.</td>
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<tr>
<td>Dr. Mark Koelmel</td>
<td>Catherine Strong</td>
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<td>VP, Chevron Energy Technology Co.</td>
<td>ConocoPhillips</td>
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<td>Byrd Larberg</td>
<td>William Thomas</td>
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<tr>
<td>Meridien Resource Corp.</td>
<td>EOG Resources, Inc.</td>
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</table>

strategic goals, 3) re-establishment of our sedimentary and petroleum geosciences programs, 4) significant fund raising that enabled the establishment of the Berg-Hughes Center, 5) new scholarships and fellowships, and 6) support of field courses. Members of GEODAC have even helped the department arrange for collaborative teaching with Ph.D. scientists from industry who provided lectures and seminars with rich, restricted-access datasets for our students. GEODAC Chairs, Ron McWhorter, Kellam Colquitt, and most recently, Dr. Lee Billingsley, are alumni who have brought personal energy and passion to assist the department. Another alumnus, now
ExxonMobil Vice President, Dr. Carlos Dengo, led the department in a series of focused workshops, using emergent learning methods to refine our strategic objectives. Graduates of our department include independent oil and gas producers and vice presidents of major corporations. Some of our Ph.D. graduates are now faculty at colleges and universities while others are employed by national laboratories. Our reputation for environmental geosciences is much more recent, and we have fewer (mostly younger) graduates who are employed as environmental geoscientists. While we strive to continue strong programs in applied geosciences, we would like to increase the number of students who pursue academic careers and focus on questions of fundamental understanding and importance. As a result, we have sought advice of our council, both to maintain traditional strengths as well as build new strengths.

Recruiters

A significant number of oil and gas companies offer recruiting events in the Department. Environmental and engineering consulting firms also recruit within the Department but these events are fewer in number. Recruiting events are organized both by the department as well as the Texas A&M Career Center. They include on-campus interviews, industry seminars, industry-supported field trips to geological sites and to company research and production facilities, and social/mentoring events. The following companies recruited in the department in fall of 2009: Anadarko, BP, Chevron, ConocoPhillips, Devon, El Paso Exploration and Production, ExxonMobil, Hess, ION Geophysical, Maersk USA, Marathon, Newfield Exploration, Noble Energy, Occidental Petroleum, Questar, Shell, and Total.
Chapter 5 - Undergraduate Programs

5.1 Program Goals

The Department of Geology and Geophysics offers a number of undergraduate programs, including B.S. and B.A. degrees in Geology, a B.S. degree with an engineering geology option, and a B.S. degree in Geophysics. These programs are intended to prepare students for a number of different career tracks. We offer rigorous undergraduate degrees in geology and geophysics that allow the student to link theory with application, develop strong quantitative and field interpretation skills, and prepare students for 21st century careers in the geosciences and related fields.

The B.S. in Geology is intended to promote critical thinking, and educate students in the application of scientific skills to the study of Earth materials and geologic processes. Graduates are prepared for careers in the energy and environmental industries, and for advanced study in graduate programs. The B.A. in Geology provides a foundation in geology for students who will enter science-related careers, such as environmental law, pre-college teaching, science journalism, and resource management and marketing. This degree is not intended for students considering careers as geologists or geophysicists. Graduates will supplement their curriculum in geology with a minor designed around their career goals. The objective of the B.S. in Geophysics is to develop the knowledge and skills to apply a physics-based approach to the study of Earth phenomena, through treatment of physical and geological principles and development of mathematical tools. Graduates will be well-prepared for careers in the energy and environmental industries, and for advanced study in graduate programs.

5.2 Program Philosophy and Design

Although we realize that many of our students have very specific career goals as applied geoscientists, we believe that their college education should prepare them for a range of potential careers. The B.S. degree programs in geology and geophysics are designed to, at a minimum, prepare our students for entrance into nationally-competitive graduate programs. Therefore these degrees broadly cover the traditional geology fields, including petrology, structural geology, geophysics, geochemistry, paleontology, as well as foundational math, physics and chemistry. Elective courses can be selected to follow various tracks (described below) that specifically prepare a student for employment or advanced study in the energy, environmental or geotechnical fields. We want our graduates to have critical thinking, problem solving and communication skills that prepare them as professionals who can adjust to a changing world. The ultimate teaching tool for these skills is involvement in scientific research projects.
Dedicated students can find multiple opportunities for research experiences working with faculty and graduate students.

5.3 Program Descriptions

The first two years of all of our degree programs are similar; and are structured to provide the foundations of geosciences, including courses in geology, geophysics, math, chemistry and physics. The third year of our programs emphasizes core subjects in geology and geophysics, while the final year of our programs emphasize geological and technical electives, allowing students to customize their degree. Upper division courses are intended to provide strong backgrounds in geology and geophysics, and emphasize knowledge transfer from other sciences and mathematics to geologic problems. Current geological questions of fundamental importance are posed, and practical problems are introduced in petroleum exploration, environmental management, and civil engineering.

B.S. Geology

The B.S. in Geology provides a broad background in geologic fundamentals, requiring at least 44 credit hours in geology and geophysics. This program can be distinguished from many other geology programs by four required semesters of math courses, including differential equations, a geophysics course, and 9 semester credit hours of field geology. Geol 300 (Field Geology), taken during the summer following the junior year, serves as a capstone course in which students apply their geology knowledge to real problems and data during a six-week field season. The B.S. is the appropriate degree for students intending to pursue graduate study in geology. Students desiring employment in industry are encouraged to pursue a M.S. degree. Students are also encouraged to become involved in research problems with faculty members, and can receive credit as research hours (Geol 291 and 491). The degree also requires 14 credit hours of geology or technical electives; elective courses may be chosen for broadening, or for concentrating along a particular career track.

The Engineering Geology Option provides education at the intersection between geology and engineering, involving mitigation of geologic hazards, siting critical facilities, geotechnical evaluation for civil engineering projects, remediation, and resource evaluation. This option is designed to build on a strong foundation in geology with specialized education in environmental and engineering topics. Students are well prepared for the Association of State Boards of Geology (ASBOG) Fundamentals of Geology exam, which is required for appointment as a Professional Geologist in the State of Texas.
The Petroleum Geology Track provides students with technical preparation for eventual employment in the field of petroleum exploration and extraction. The petroleum geology track is intended to prepare students for graduate study, as well as provide training for those who may be interested in service jobs in the oil and gas industry between their undergraduate education and entry to a graduate program.

The Environmental Geology Track is designed to provide a strong foundation in geology coupled with specialized education to address pressing societal problems, including groundwater contamination and remediation, non-point-source pollution, water resources, and geologic hazards. Students completing the environmental track of the B.S. in Geology are prepared to go on to graduate school for an advanced geoscience degree, or for employment in the environmental industry. Students are well prepared for the Association of State Boards of Geology (ASBOG) Fundamentals of Geology exam, which is required for appointment as a Professional Geologist in the State of Texas.

**B.A. Geology**

The B.A. in Geology provides a foundation in geology for students who are not planning a career as a geologist. The B.A. in Geology is distinguished by the requirement of a minor. This program provides a basis for science-related careers, such as environmental law, pre-college teaching, science journalism, and resource management and marketing. Graduates supplement their curriculum in geology with a minor designed around their career goals. The minor requires a minimum of 15 credit hours in one discipline, to be chosen in consultation with an advisor.

**B.S. Geophysics**

The B.S. in Geophysics is distinguished by over three years of math (20 required semester credit hours), and additional physics and geophysics courses (25 required semester credit hours), including field and theoretical geophysics courses. Geophysics majors automatically qualify for a minor in Math. Four 400-level courses in geophysics during the junior and senior year emphasize knowledge transfer from the fields of math and physics to techniques and problem solving in theoretical and applied geophysics. Twelve credit hours of technical electives allow students to focus on specific career objectives. Environmental and petroleum tracks prepare students for the most common career paths for geophysicists. Students are also encouraged to become involved in research problems with faculty members, and can receive credit as research hours (Geop 291 and 491).

The Petroleum Geophysics Track prepares students for eventual employment in the petroleum industry, in which reflection seismology is the primary subsurface exploration tool. Students in this track supplement their background in seismic theory with electives that focus on subsurface
structures and processes, and industry techniques. The petroleum geophysics track is intended to prepare students for graduate study, as well as provide training for those who may be interested in service jobs in the oil and gas industry between their undergraduate education and entry to a graduate program.

The Environmental Geophysics Track focuses the geophysics degree on traditional and emerging methods used for hydrogeological, structural and stratigraphic characterization of the uppermost 100 meters, with applications to shallow resource and groundwater assessment and the solution of environmental and engineering problems. Students completing the Environmental track of the B.S. in Geophysics are prepared for graduate school, or for employment in the environmental industry. Environmental geophysicists typically work as independent environmental consultants or with industrial corporations or government agencies.

**Catalogue Listings**

Catalogue descriptions of all four undergraduate degree programs offered by the Department of Geology and Geophysics are provided in *Tables 5.1 to 5.4*. Detailed descriptions of geology and geophysics courses appear in *Appendix B*, followed by undergraduate research projects and student participation in ongoing research, and the department's Program Assessment Plan.

Students pursuing the Petroleum Geology Track may take a number of electives in geology and petroleum engineering, including Geol 400 (Reservoir Description), Geol 404 (Geology of Petroleum), Pete 311 (Reservoir Petrophysics), Pete 321 (Formation Evaluation), Pete 324 (Well Performance), or Pete 402 (Petroleum Property Management). Students with strong grades (GPA of 3.0 or better) may enroll in graduate courses, including Geol 619 (Petroleum Geology), Geol 622 (Stratigraphy), Geol 623 (Carbonate Rocks), Geol 624 (Carbonate Reservoirs), Geol 668 (Clastic Sedimentology and Sedimentary Petrology), or Geop 629 (Seismic Interpretation).

Students pursuing the Environmental Geology Track may take geology and technical electives in engineering, geography, and background sciences, such as Geol 410 (Hydrogeology), Geol 420 (Environmental Geology), Geol 440 (Engineering Geology), Geos 410 (Global Change), Geog 331 (Geomorphology), Geog 390 (Principles of GIS), Cven 365 (Introduction to Geotechnical Engineering), or other courses offered in Departments of Civil Engineering, Soil and Crop Science, Chemistry, and Physics.

Students pursuing the Petroleum Geophysics Track may benefit from such courses as Geol 306 (Sedimentology and Stratigraphy), Geol 400 (Reservoir Description), Geol 404 (Geology of Petroleum), Pete 201 (Introduction to Petroleum Engineering), Pete 311 (Reservoir Petrophysics), and Pete 320 (Drilling and Production Systems). Students planning careers in
# Table 5.1. Bachelor of Science Geology Degree Requirements (2009 – 2010)

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<th>Fall</th>
<th>First Semester</th>
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<th>Cr</th>
<th>Spring</th>
<th>Second Semester</th>
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**Notes**

1. These electives must be selected from the approved list of courses satisfying the University Core Curriculum.
2. These electives must be selected from the approved list of courses satisfying the University Core Curriculum AND 6 hours must be selected from courses that also satisfy the International and Cultural diversity requirement.
3. Any approved 400-level geology or geophysics course not already required.
4. Any science, math or engineering course that augments the degree with the approval of the advisor.
### Table 5.2. Bachelor of Science Geology, Engineering Option (2009 – 2010)

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</table>

**Notes**

1. These electives must be selected from the approved list of courses satisfying the University Core Curriculum.
2. Any science, math, or engineering course that augments the degree with the approval of the advisor.
3. These electives must be selected from the approved list of courses satisfying the University Core Curriculum AND 6 hours must be selected from courses that also satisfy the International and Cultural diversity requirement.
Table 5.3. Bachelor of Arts in Geology (2009 – 2010)

<table>
<thead>
<tr>
<th>Fall</th>
<th>First Semester</th>
<th>(Th-Pr)</th>
<th>Cr</th>
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Notes
1. May substitute MATH 141 for MATH 166; may substitute MATH 142, 151 or 171 for MATH 131.
2. These electives must be selected from the approved list of courses satisfying the University Core Curriculum.
3. May substitute PHYS 218 for PHYS 201; may substitute PHYS 208 or 219 for PHYS 202.
4. Fifteen hours of electives must be selected in a minor. Electives must be chosen in consultation with advisor.
5. Any 300- or 400-level geology or geophysics course not already required.
6. Any science, math, engineering or social science course that augments the degree with the approval of the advisor.
7. These electives must be selected from the approved list of courses satisfying the University Core Curriculum AND 6 hours must be selected from courses that also satisfy the International and Cultural diversity requirement.
8. General electives MAY NOT include BUAD 100; STLC 001-499; SLGX 001-499; ENGL 100, 103; GEOL 101-104; KINE 198, 199; LBAR 201; MATH 102, 103, 104, 141, 142, 150, 151, 166, 171; AERS 100-499; MLSC 100-499; NVSC 100-499; SOMS 100-499.
## Table 5.4. Bachelor of Science in Geophysics (2009 – 2010)

<table>
<thead>
<tr>
<th>Fall</th>
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<th>Cr</th>
<th>Spring</th>
<th>(Th-Pr)</th>
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| SOPHOMORE YEAR | | | | | | 14 |
| GEOL 203 | Mineralogy | (2-6) | 4 | GEOL 302 | Introduction to Petrology | (3-3) | 4 |
| GEOP 341 | Introduction to Global Geophysics | (3-0) | 3 | GEOL 309 | Introduction to Geologic Field Methods | (1-6) | 3 |
| MATH 251 | Engineering Math. III | (3-0) | 3 | MATH 308 | Differential Equations | (3-0) | 3 |
| PHYS 218 | Mechanics | (3-3) | 4 | PHYS 219 | Electricity | (3-3) | 4 |
| *KINE 198 | Health and Fitness Activity | (0-2) | 1 | *KINE 199 | Required Physical Activity | 1 |
| **Total Credits** | | | | | | 15 |

| JUNIOR YEAR | | | | | | 15 |
| GEOP 435 | Principles of Geophysical Exploration | (3-3) | 4 | GEOP 413 | Near-Surface Geophysics | (3-0) | 3 |
| PHYS 221 | Optics and Thermal Physics | (3-0) | 3 | GEOL 312 | Structural Geology and Tectonics | (3-3) | 4 |
| U.S. history or political science elective ³ | 3 | MATH 311 | Topics in Applied Math | (3-0) | 3 |
| Computer science ² | 3 | GEOL 311 | Principles of Geological Writing | (1-0) | 1 |
| Visual and performing arts elective ³ | 3 | | | |
| **Total Credits** | | | | | | 16 |

| SENIOR YEAR | | | | | | 17 |
| GEOP 421 | Petroleum Seismology I | (3-3) | 4 | GEOP 470 | Computational Methods | (3-0) | 3 |
| MATH 412 | Theory of PDES | (3-0) | 3 | | Technical electives ⁴ | 8 |
| Technical elective ³ | 4 | | | | U.S. history or political science elective ¹ | 3 |
| Humanities elective ³ | 3 | | | | | |
| **Total Credits** | | | | | | 14 |

**Total Credits** | | | | | | 120 |

**Notes**
1. These electives must be selected from the approved list of courses satisfying the University Core Curriculum.
2. Computer science course must entail programming with a high-level language.
3. These electives must be selected from the approved list of courses satisfying the University Core Curriculum AND 6 hours must be selected from courses that also satisfy the International and Cultural diversity requirement.
seismic theory may wish to take additional courses in physics, mathematics, or electrical engineering, such as Math 417 (Numerical Analysis I) or Ecen 444 (Digital Signal Processing). Students with strong grades (3.0 or better) may enroll in graduate courses Geop 629 (Seismic Interpretation) or Geop 622 (Petroleum Seismology).

Students pursuing the Environmental Geophysics Track may take Geol 410 (Hydrogeology), Geol 420 (Environmental Geology), Geol 440 (Engineering Geology), Cven 365 (Introduction to Geotechnical Engineering), or other courses offered in Departments of Civil Engineering, Soil and Crop Science, Chemistry, and Physics.

Reinforcement of Communication Skills and Problem Solving

The undergraduate programs in geology and geophysics have been strengthened, much as other undergraduate programs at Texas A&M University, by the introduction of writing-intensive courses that are taught by our faculty as part of the geology and geophysics curricula. Writing-intensive courses (Geol 311, Geol 312, Geol 301, Geol 420, and Geol 440) offer instruction in scientific writing, and require that students rewrite papers and reports in response to the instructor's questions, marked criticisms, and calls for revision.

The department has also attempted to assist students with their math and problem-solving skills by offering in-house one-on-one tutoring. We are fortunate to have a retired aeronautical engineer, Mr. Henry Geneczko, who has offered his time and effort to tutor geology and geophysics students enrolled in math and physics courses on a weekly basis. Mr. Geneczko has 38 years of engineering experience, applying math to practical problems. Tutoring sessions are scheduled in one of our conference rooms (Halb 103). While relatively few of our students have taken advantage of this resource, those who visited Mr. Geneczko had a positive experience.

Field Courses

A hallmark of our undergraduate programs is the inclusion of field work and field observations, both in the geology and geophysics curricula. All students take Introduction to Field Methods (Geol 309), and several required courses contain field trips. Geology B.S. students also take Geology Field Camp (Geol 300) for a total of 9 credits of formal field work. Geology B.A. students take a total of 6 credit hours, including at least one of multiple sections of Geology Field Trips (Geol 330), which range in duration from several days to 2 weeks, at locations throughout Texas and southwestern USA. Geophysics B.S. are introduced to field work in geophysics through Principles of Geophysical Exploration (Geop 435) and Near-Surface Geophysics (Geop 413). Many of our students take additional field courses; for example, some of our B.A. Geology students enroll in Summer Field Geology (Geol 300) and many B.S. students take Geol 330.
recent innovation is to teach Geol 309 and Geop 435 back-to-back applying geological field methods and then geophysical surveying methods in the same field area (Figure 5.1).

At a time when many geoscience programs are cutting back on field courses (2009 AGI Geoscience Workforce Program report on four-year Geoscience Programs, http://www.agiweb.org/workforce/reports.html), we have maintained strong field courses that reinforce the student's understanding through mapping, data collection, and interpretation. Enrollments in field courses have increased greatly (Figure 5.2) requiring additional sections of Geol 309 and Geol 300. Teaching field courses offers many challenges, but members of the department believe firmly in the value of asking students to apply what they have learned from all major courses of the degree program to solve hands-on field projects. Members of our Advisory Council have confirmed the importance of maintaining field-intensive courses, and we have recently received a generous donation from Chevron USA to pay student field course fees for three consecutive years of Geol 300, in addition to field scholarships for 30 students (Figure 5.3).

Figure 5.1. Undergraduate Field Geology and Geophysics Methods Courses
Figure 5.2. Undergraduate Enrollment in Field Courses

Figure 5.3. Summer Field Geology (Geol 300)
Undergraduate Research

Although many of our undergraduate students are busy with the required coursework of the Geology and Geophysics Degree Programs, a number of students take advantage of research opportunities (Appendix B). Students can pursue individual or small group directed studies with faculty at both upper division and lower division levels (Geol 485, Geop 485, Geol 285) or engage in research projects (Geol 491, Geop 491, Geol 291). Some undergraduate students are employed in the department as research assistants, funded by research grants, or as laboratory assistants. Several of these undergraduate research projects have led to peer-reviewed publications. For example, the senior thesis of Andrew Munoz, an Undergraduate Research Scholar working with Dr. Everett, was selected for publication in the inaugural issue of Explorations, the Texas A&M Undergraduate Journal. A number of our undergraduates are even co-authors

Scholarships

Geology and geophysics students are awarded a number of merit-based scholarships, which come from annual contributions to the department and earnings from named endowments. More than thirty undergraduate geology and geophysics students received scholarships in fall, 2009; these scholarships are listed in Table 5.5.

Table 5.5. Undergraduate Geology and Geophysics Scholarships

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<tr>
<th>Scholarship</th>
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<td>Robert R. &amp; Josephine F. Berg Scholarship</td>
<td>Priscilla and Thomas E. Kelly Scholarship</td>
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<tr>
<td>BP First Generation Scholarships</td>
<td>Dustin and Beth Marshall Scholarship</td>
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<td>Mel and Debbie Friedman Scholarship</td>
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<td>Joe S. Farmer Memorial Scholarship</td>
<td>KG &quot;Red&quot; McCann Scholarship</td>
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<td>Geology-Geophysics Scholarships</td>
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<td>Robert M. Golding Jr. Scholarship</td>
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<td>Stuart P. Hinchey Scholarship</td>
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<td>J.R. and Norine Jackson Scholarship</td>
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Earth Sciences Degree

At the time of our last review, the Department of Geology and Geophysics offered a B.S. in Earth Sciences. This degree program was designed to prepare students to become Earth science teachers in the state of Texas. This degree was phased out about 3 years ago when the State of Texas changed its regulations concerning the preparation of middle school science teachers. The education of middle school science teachers is now administered by the College of Education.

Environmental Geosciences Program

Since our last review, the College of Geosciences has initiated a new Environmental Program in Geosciences (Envp). This interdisciplinary program engages students in the study of the Earth as an environmental system, addresses how the Earth system functions, and how people interact with the Earth. This program also includes studies of environmental policy and management. Students are introduced to environmental research in the lab and in the field, and advisors actively work with students to find internships and guide students toward opportunities for advanced study. Students may work towards a B.S. in Environmental Geosciences or a B.S. in Environmental Studies. The B.S. in Environmental Geosciences is an interdisciplinary geosciences degree with course content drawn from Atmospheric sciences, Geology and Geophysics, Oceanography, and Geography. Key courses offered by our department include Environmental Geology (Geol 420) and Hydrogeology (Geol 410). The B.S. in Environmental Geosciences requires 15 hours of geoscience electives. The B.S. in Environmental Studies requires 6 hours of geoscience electives.

5.4 Undergraduate Student Profiles

Despite the rigor of our undergraduate Geology and Geophysics Degree Programs, the enrollment of majors has grown dramatically (Figure 5.4). In 2002, our undergraduate population of about 120 students was dominated by Geology B.S. majors, with only 10 Geophysics B.S. majors. Student numbers remained nearly constant until 2006, when our enrollments began to increase. In recent years, our student numbers have increased each year, with 219 majors (~50 in Geophysics) enrolled at the time of this report. While geoscience student enrollment data in AGI's 2009 Geoscience Workforce Report (http://www.agiweb.org/workforce/reports.html) only extend to 2007, no such trend of increasing numbers is apparent nationwide (Figure 5.5). Instead, the total number of undergraduate geoscience majors in the U.S. show a decline from nearly 22,000 in 2002 to about 19,000 in 2007 (dropping 3%/year). Mean numbers of students in geoscience departments of individual colleges and universities show a decline from about 60 students in 2002 to 45 (less than 1/3 our enrollment) in 2007.
Figure 5.4. Undergraduate Enrollment in Department of Geology and Geophysics; Total Number of Majors and Geology (B.S. and B.A.) and Geophysics B.S. Students

Figure 5.5. Nationwide Geoscience Student Enrollments (2009 AGI Geoscience Workforce Program)
The rise in our student numbers correlates well with oil prices. Conversations with our students indicate that our rising enrollments are due to increased interest in applied petroleum industry careers. Most of our undergraduate majors are in-state students, and we expect that Texas high school students are more aware of careers in petroleum geosciences than elsewhere in the nation.

Irrespective of the growth in student numbers of the Department, our student profiles do not appear to have changed much. Combined SAT scores of incoming undergraduate students have averaged ~1200 over 2002 to 2009 (Figure 5.6). The average number of years taken by our undergraduate students to complete degrees in geology and geophysics exceed the time anticipated to complete our degree programs by just over a year (Figure 5.7). Average years taken to complete Geology degrees are consistently over five years from 2003 to 2008 (data for geophysics majors are erratic due to small enrollments). However, it is important to recognize that many students transfer into Texas A&M University as juniors without completing the first two years of our degree plans. In addition, many students who attend Texas A&M University must work during the school year to meet their college expenses, leading to increased times to graduation.

Figure 5.6. SAT Scores by Major (mean values and maximum/minimum scores of incoming freshman)
Texas A&M University has established the goal to diversify its students and faculty. At present, neither the students nor faculty reflect the population of Texas. The Department of Geology and Geophysics is particularly challenged to increase student and faculty numbers of under-represented groups. With respect to students, we do not receive many applications from prospective under-represented students. Moreover, the diversity of students entering geosciences is a nationwide problem. Tracking our undergraduate enrollments by under-represented minority and gender (Figures 5.8 and 5.9, respectively), the geology and geophysics student body includes only ~11% Hispanic and African American students, and only ~33% female students. While our student population is more diverse than the national average for geosciences (just 2% over 1993-2004, combining African American, Hispanic, and Native American students; 2009 AGI Geoscience Workforce Program), we are disappointed that our student population falls so far short of 50% by gender (45% is the national average of geoscience bachelor degrees conferred to women in 2007; 2009 AGI Geoscience Workforce Program). This is perhaps related to the petroleum focus of the majority of our students: women comprise only about 20-25% of the petroleum workforce worldwide. We recognize that our department is not diverse in its faculty. Unfortunately, this follows directly from national trends of under-representation amongst geoscience students.
5.5 Courses Offered to Non-Majors

The Department of Geology and Geophysics offers large numbers of introductory core science courses to non-science majors at Texas A&M University, including Principles of Geology (Geol 101), its Honors Program equivalent (Geol 101H), Historical Geology (Geol 106) and Dinosaur World (Geol 307). Annual enrollment in Geol 101 is 2500 students, which means that one out of every four TAMU students takes a geology course by the time they graduate. Geol 101H sections
are intentionally small (annual enrollments of just 60), to provide students excellent access to faculty. Annual enrollments of Geol 106 are typically about 200. At the same time that our introductory science courses serve the Vision 2020 imperative to offer broadening core courses that are particularly interesting to students in Texas, we are able to support a significant number of graduate students, who serve as teaching assistants (GATs) to Geol 101 laboratory sections of just ~20 students each.

A few upper level classes get significant enrollment from non-majors, in particular Structural Geology, Petroleum Seismology and Petroleum Geology, which are part of the Petroleum Engineering curriculum.

5.6 Administration

The department's Curriculum Committee (Table 3.5) oversees degree requirements and the course inventory. Geology and geophysics majors are advised by faculty, with students assigned to advisors according to degree program (advisors come from the Undergraduate Advisors Committee, Table 3.6). The department's Office Associate, Ms. Gwen Tennell, assists students and advisors access the university's records and degree auditing services.

Recruiting into Geology and Geophysics

With rapidly increasing undergraduate student numbers, our focus is not to increase student numbers but to recruit diverse, first-generation, and outstanding students to our undergraduate programs. Recruiting of undergraduate majors to the geosciences is overseen and managed by the Office of the Dean of Geosciences. The College hired a recruiter, who focuses on undergraduate recruiting of under-represented students. Dr. Sonia Garcia, the College recruiter, has developed an undergraduate recruiting program, which focuses on developing ties with inner-city school districts and school districts with high percentages of economically-disadvantaged students. To date, contact has been made with numerous school districts around Texas, as well as meeting with teachers at the recent Conference for Texas Science Teachers. In addition, the College has a program to bring a number of outstanding junior and senior high school students to the Texas A&M campus for a three-day visit. This approach should help increase the number of outstanding students choosing to major in the geosciences.

Faculty are not involved with decisions of admission of undergraduate students at Texas A&M University. Admission decisions are made at the university level. By state law, any student graduating in the top 10% of his/her high school class is guaranteed admission to any Texas university, and these students make up a large percentage of each freshman class. The Department
has the freedom to set higher standards for admission into our degree programs, but currently does not do so.

Simultaneous to College efforts to recruit new majors into the geosciences, faculty of the Department of Geology and Geophysics (Drs. Giardino and Vitek) run a popular summer program for Texas high school science teachers known as G-Camp (http://www.science.tamu.edu/articles/611), which introduces teachers to field geology. G-Camp takes a continental transect from Texas to Colorado, illustrating shoreline processes in Galveston, TX to rock glaciers of the San Juan Mountains, CO. Participants are selected for their enthusiasm and for school districts that may help our department attract diverse, under-represented high school students. G-Camp is also envisioned for incoming TAMU students in future years. Funding for G-Camp has generously been provided by Baker Atlas Hughes, BP, Chevron, ConocoPhillips, ExxonMobil, and Halliburton.

5.7 Program Assessment and Outcomes

In 2008 the Department initiated a comprehensive program assessment of the goals and outcomes of the various degree programs as part of a TAMU-wide program. This process identified several learning goals for each degree program: 1) a broad understanding of geologic fundamentals relevant to each degree program; 2) knowledge transfer from other sciences; 3) geologic field skills; 4) communication skills; and 5) the opportunity to participate in research. We instituted student surveys and developed an optional capstone test of geologic concepts, which we began to administer in spring 2009.

Entrance Survey

An entrance survey has been developed, which will be filled out by incoming students each semester beginning this spring 2010. The survey seeks information on the students' background in Geology/Earth Science, fundamental science, and math. Each student is asked 1) why she/he chose geology/geophysics as a major, 2) why he/she chose TAMU, and 3) what her/his career goals are. One of the objectives of the survey is to compare perceptions and intentions of new students with those of graduating students.

Capstone Exam

We administered a pilot version of the capstone exam to eleven students graduating in spring, 2009. It consisted of approximately 30 questions taken from the content of seven core courses for each major. None of the students achieved our target score of 75%, despite other indications of
their success. We are revisiting the questions we posed in this first exam and plan to ask broader questions that test fundamental understanding in the next exam.

**Texas Licensure Exam**

The ASBOG Licensure Exam will be used to assess Geol B.S. majors in the Engineering Geology option. We have anecdotal evidence that indicates our students do well compared to those from other institutions. However, only two engineering geology students have graduated since spring 2009, when we first began the assessment process. Both of those students enrolled in graduate programs, and postponed taking the ASBOG exam.

**Writing Assessment**

A section of the University-approved writing-intensive course (Geol 311, Geological Writing) of the Department was evaluated by submitting papers written by 18 students in a spring 2009 section of Geol 311 to the Office of Institutional Assessment and University Writing Center. The overall assessment score of 2.150 was comparable to the campus-wide average of 2.158, just above the numerical score of 2.0 for "meets expectations."

**Exit Survey**

For the 2008-09 year, the exit survey did not distinguish between Geol B.A., Geol B.S., and Geop B.S. majors. For the year, 14 of the 28 (50%) graduates completed the exit survey. Of those responding, 43% were accepted into graduate programs, and 43% accepted permanent employment in the geosciences (one as a commissioned officer); 86% felt that their undergraduate education prepared them for their careers. Of undergraduate students responding, 29% had a summer internship before graduating, and 35% had taken part in undergraduate research.

**5.8 Strengths and Challenges of Undergraduate Programs**

Our undergraduate program has been successful in its primary goal, of preparing students for graduate school and jobs. Of graduating students surveyed at the end of the 2008-2009 academic year, 86% enrolled in graduate programs or obtained employment in the geosciences. In the last four years alone, our graduates have been accepted into some of the top geology and geophysics graduate programs in the country (including MIT, Rice, Stanford, Univ. Washington, Univ. Texas, Colorado School of Mines, Univ. Wisconsin and Univ. Minnesota). Between 1991 and 2006, 29 former B.S. graduates from our department were granted doctorates (*Baccalaureate Origins of S&E Doctorate Recipients*, NSF 08-311, 2008), tied for 39th among all U.S. schools. Considering the applied career goals of the majority of our students, this is a good number.
Significant numbers of undergraduate students engage in research projects inside and outside the department. One third of our undergraduates take part in research by the time they graduate. Also, about one third of our undergraduates are selected for industry internships. Graduating students express overall satisfaction with the program and 86% agree that our programs prepared them for their careers.

The number of geology and geophysics students in our department has more than doubled in the last three years. As a result, most of the required core courses in Geology (Historical Geology, Mineralogy, Global Geophysics, Petrology, Structure, Field Methods, Geologic Writing) have been expanded to two lecture sections per year (up to four in the case of writing-intensive courses). If enrollments continue to rise at present rates, we will either be unable to meet our goal of maintaining small, high quality courses for geology and geophysics students, or we will need to reduce the number of service courses we offer to non-majors. Rather than experience unchecked growth of our student population, we may need to manage student enrollments, by developing standards for entry into our majors. We also face a long-term challenge to diversify our undergraduate student population, and attract more African American and Hispanic students, as well as women to Geology and Geophysics to reflect the population of Texas. We continue to offer G-Camp to high school science teachers to increase the department’s diversity, and we are investigating the possible effects of instituting additional requirements (such as a GPA minimum) on student number and quality.
Chapter 6 - Graduate Program

6.1 Program Goals

The Department offers several graduate degrees including the M.S. in Geology, M.S. in Geophysics, Ph.D. in Geology, and the Ph.D. in Geophysics. In addition, departmental faculty advise graduate students enrolled in two interdisciplinary graduate programs administered through the College of Geosciences, the M.S. in Geosciences and the M.S./Ph.D. in Water Management and Hydrologic Sciences. The M.S. programs prepare graduate geology and geophysics students for professional careers, mostly in the fields of energy and environmental geosciences. The Ph.D. programs are intended to provide students with expertise in one or more specialties and the ability to lead an original research project, in preparation for academic teaching and research careers.

6.2 Program Overview and Philosophy

The Department of Geology and Geophysics currently has 62 students seeking a M.S. in Geology, 14 students seeking a M.S. in Geophysics, 23 students seeking a Ph.D. in Geology, and 12 students seeking a Ph.D. in Geophysics. We advise about ten students in the University's Water Program. About 30% of our graduate students are pursuing Ph.D. degrees, 59% are American, 37% are women, and 15% of our domestic students come from under-represented groups.

The Department's graduate programs are intended to provide students with depth and breadth, in the form of a T-shaped program: deep disciplinary expertise coupled with broad knowledge. Expertise is developed through the student’s thesis or dissertation research project, while breadth is developed through courses, seminars, and field trips. Some programs within our degrees (Tectonophysics, Petroleum Certificate) enforce breadth with a short list of required classes.

While students commonly focus much of their attention on developing their specialty, it is ultimately important that they are able to apply their knowledge and skills to a range of new and emerging scientific questions or societal problems. Bransford (2000; How People Learn, NRC National Academy Press) describes this type of background as adaptive expertise. We want our graduates to approach new situations and problems with flexibility, to be lifelong learners, and have strong problem-solving skills.
6.3 Degree requirements

Each graduate student in the TAMU Department of Geology and Geophysics develops a unique degree plan, in consultation with the student's research advisor and research committee. Courses listed on the student's degree plan are intended to develop the student's area of specialization and provide necessary breadth according to the student’s career goals. Geology and geophysics graduate course descriptions are listed in Appendix C along with lists of current students, theses and dissertations over 2002-2009, peer-reviewed journal publications that students have authored/co-authored, and our Graduate Program Assessment Plan.

Master of Science

Texas A&M University specifies that all M.S. Programs are designed to help students develop new understanding through research and creativity. The University requires a minimum of 32 semester credit hours of approved coursework and research for the Master of Science Degree, with at least 23 hours in formal coursework, two credit hours of seminars, with a nine credit hour minimum residency requirement. Each student engages in research with a formal faculty advisor of the department and an advisory committee, which consists of at least three members of the graduate faculty. One committee member must be outside the department.

Students file an approved degree plan and thesis proposal with the University's Office of Graduate Studies, defend their thesis before the graduate advisory committee and submit their thesis to the University's Thesis Clerk.

Doctor of Philosophy

Texas A&M University specifies that all Ph.D. Programs give the student a thorough and comprehensive knowledge of the student's chosen professional field. The successful doctoral student is to demonstrate ability to do independent research and be able to express thoughts clearly and forcefully, verbally and in writing. The university requires a minimum of 64 credit hours on an approved degree plan that includes formal coursework, seminars, and nine residency credit hours. The Department of Geology and Geophysics specifies that Geophysics Ph.D. candidates take four core courses, Geop 611, Geop 652, Geop 660, and Geop 666. The student's graduate research committee must include at least four members of the graduate faculty, with one faculty member from another department. Doctoral candidates must pass a preliminary examination, which consists of written examinations provided by each committee member, and an oral examination. Students file research proposals and complete their degree by passing a Dissertation Defense and filing an approved Ph.D. Dissertation with the university's Thesis Clerk.
Petroleum Certificate

For students wishing to pursue careers in petroleum geosciences, the Department offers a Petroleum Certificate, which can be applied to a M.S. or Ph.D. diploma in either Geology or Geophysics. The Graduate Certificate in Petroleum Geosciences does not substitute for M.S. or Ph.D. degrees or requirements to complete a thesis or dissertation. Rather, it indicates preparation for careers in the energy industry, through core courses, internship presentations, and enrichment activities designed to serve as a base for original research. Core courses consist of 1) Sequence Stratigraphy or Basin Architecture (Geol 622 or Geop 628), 2) a 3D Structural Geology Course (e.g., Geol 612), 3) Reflection Seismology (Geop 629 or Geop 622), 4) a course in rock properties (Geol 624, 665, or 668), and 5) one seminar per year in Petroleum Geoscience or a related topic. Students may take courses in Departments of Geology and Geophysics or Petroleum Engineering. These core courses may be part of the student’s degree plans for M.S. or Ph.D. degrees. The Certificate is awarded on completion of the MS or Ph.D. in the Department of Geology & Geophysics.

6.4 Advising

Advising graduate students is primarily the responsibility of individual faculty, who work one-on-one with students seeking M.S. or Ph.D. degrees. Students receive further advice and feedback from their graduate advisory committee. Some M.S. students enter our graduate program without a designated advisor; the department’s Graduate Program Coordinator provides general advice on our programs and curriculum until the student has found a faculty advisor.

6.5 Recruitment and Admissions

To address challenges identified in our previous program review, the Graduate Coordinator, Dr. Herbert, and Graduate Committee were charged in 2007 with three initiatives: 1) support a change in departmental culture that increases publication rates among graduate students, 2) increase the percentage of Ph.D. students, and 3) improve the quality of our graduate students. Our efforts have focused on three sets of activities.

Graduate Student Recruitment Initiatives

We have evaluated and enhanced our graduate student recruiting, focusing on four, interconnected activities.

Recruiting at National Meetings We have attempted to improve recruiting at national meetings. At each of the last three national meetings of the GSA, faculty and students organized a schedule
to man the Department’s recruiting booth, which included graduate program brochures and a poster. Owing to the enthusiasm of our graduate students, the booths were busy at all meetings (Figure 6.1), and numerous prospective students inquired about our programs. However, only a fraction of those who signed up for further information actually joined our program. As an example, 74 names and e-mail addresses were compiled during the 2007 GSA Meeting. Following the meeting, faculty with interests similar to those of prospective students corresponded by e-mail, leading to 9 graduate applications. Of these, six applicants were accepted by the department's Graduate Committee, and three enrolled in our graduate program.

Faculty and a former student of Departments of Geology and Geophysics and Oceanography attended a Joint Conference of the National Societies of Black and Hispanic Physicists over Feb. 11-15, 2009 and hosted a recruiting booth with the TAMU Physics Department. We expect that few members of under-represented minorities are aware of career opportunities in the geosciences. A dozen African American physics students signed up for further information about geophysics and/or oceanography. Neither department succeeded in attracting applicants from this pool, but we will attempt this strategy to diversify geophysics graduate students again.

**Figure 6.1. Graduate Student Recruiting 2007 National GSA Meeting**

**Internet Recruiting.** The Internet is our most important recruiting tool. We are pursuing two initiatives. First, we continue to improve our web site to highlight our strengths and the nature of our program. Second, we are attempting to design a responsive system that sends e-mails to potential applicants based upon their research interests.
Recruiting Weekend. One of the more successful recruiting initiatives is our recruiting weekend, which is scheduled for a long weekend in early spring. Prospective graduate students who have been accepted to our program are invited to visit the department. Many of our current graduate students found this event helpful in making their decisions to join the department. However, we have probably lost students to early offers from other programs by holding this event too late in the spring semester. Thus, we have advanced the dates of this event to March 4-7, 2010.

Faculty Presentations at Geoscience Departments. We have generated a list of four-year colleges and universities with strong undergraduate geoscience programs with the goal of visiting departments to give undergraduate seminars. A few faculty (e.g., Dr. Herbert) have been successful recruiting students this way, and faculty with few graduate students are encouraged to pursue this strategy. Thus far, few faculty have contributed to this initiative.

Improvements in Application Management

The graduate committee has come to the consensus that attracting excellent candidates to our program requires that, i) the application review process is quick and responsive, ii) faculty inform the graduate committee of the number of students they seek to add to their research group, and iii) all students have an advisor when they join the department. In order to facilitate quick decisions and make offers to excellent students in shorter times, three solutions have been initiated, two of which involve improvements in IT-based management: 1) the graduate committee uses a server-based system to manage graduate applications, so that applications are seen in parallel rather than in series, 2) a database is created that generates reports for faculty, informing them of new applicants, and 3) the graduate committee has adjusted its management and scheduling of fellowship decisions so that fellowship offers to new, prospective students can be made quickly.

Graduate Fellowships

The graduate committee has formulated criteria for fellowships that should allow us to attract outstanding students to the department, and reward academic excellence and graduate student research of students who are already in our department. The graduate fellowship criteria (as described in Section 6.6) emphasize research publication, weighted for the time a graduate student has been enrolled.

Outcomes of Our Initiatives

Our efforts have had some positive outcomes in recent years. We have become more selective, as indicated by decreased applicant acceptance rates (Figure 6.2), while more of the students we accepted last year came to Texas A&M University. We have attempted to apply higher standards for admission to our program, targeting students with stronger backgrounds, better
grades and higher GRE scores. Yet, when we compile combined GRE scores of students entering our graduate programs, the desired increase in mean, maximum and minimum scores in recent years is not apparent (Figure 6.3). In part this is explained by a number of international students whose verbal GRE scores are relatively low but whose TOEFL scores are good. In addition, we have been sensitive to requests of faculty who identified students with common research interests. GRE scores of students admitted to our graduate program in fall, 2009, are highly skewed, with median GRE scores (~1200) of incoming geology and geophysics students that are higher than mean values compiled by the university's Office of Institutional Studies (OISP).

![Figure 6.2. Percentages of Graduate Student Applicants Admitted (% in blue) and Graduate Students who Accepted our Offer and Enrolled (% in red)]
6.6 Financial Support

Owing to the Department's commitment to teaching introductory core science courses, many of our graduate students are supported as graduate teaching assistants (GATs, Figure 6.4). Ten to 20 graduate students are typically supported as research assistants (GARs), based on extramural research grants. In recent years, we have benefited from industry contributions to graduate student support, leading to increased numbers of graduate fellowships.

Fellowship/Scholarship Application & Selection Process

The Department of Geology and Geophysics receives generous annual donations from a number of petroleum companies and we have a number of graduate student endowments that we can use for graduate fellowships and scholarships (Table 6.1). Graduate Fellowships of $20,000 to $25,000 are awarded to graduate students, providing full support for two semesters, on the basis of merit. The Department awards scholarships in amounts ranging from $2000 to $5000, which can supplement other forms of support (GATs, GARs, or Fellowships). The number of fellowships has increased in recent years due to an increase in number of gifts. The Graduate Committee made the decision to use increased funds to make offers with full fellowship/scholarship support, as opposed to making many offers of partial support. In 2009-10, 15 fellowships and 8 scholarships were awarded to 22 students, totaling $370,615.
About half of the available fellowships are reserved for recruiting new students; these are awarded by the Graduate Committee when new applications are reviewed in the spring semester. Fellowships and scholarships are awarded to current students once a year on a merit basis. Graduate students submit an application listing their accomplishments and activities, and faculty advisors provide short recommendation letters. Members of the Graduate Committee score students in four areas, and these scores are combined with the following weights:

1. Academic Progress (70%): research publication (peer-reviewed papers and abstracts) and class performance (GPA)
2. Indications of Scholarly Excellence (10%): external awards, fellowships
3. Indications of Career Development (10%): internships, participating in meetings, cruises and workshops, significant participation in proposal writing, mentoring, and teaching
4. Service (10%): positions in student organizations, participation in recruiting

The highest-scoring students are matched with awards, taking into account restrictions that particular fellowships may have (such as degree program or field of study specified in donor letters of intent).
Table 6.1. Graduate Fellowships and Scholarships in Fiscal Years 2008-09 and 2009-2010

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<tr>
<th>Amount ($)</th>
<th>Number of Awards</th>
<th>Award Name</th>
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<tr>
<td><strong>Fall 2008/Spring-Summer 2009</strong></td>
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</tr>
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6.7 Graduate Student Profiles

The total graduate student enrollment of 111 students this year is similar to the total in 2002 (just over 100) (Figure 6.5). However, in the interim, the department experienced a significant drop in students, and over this time period the percentage of PhD students has dropped, from about 40% to 33%. These changes are primarily due to variations in the number of M.S. students, and can be related to the developments in the petroleum industry and the faculty make-up.

From 2002 to 2005, graduate student numbers decreased 3%/year, following the national trend in geoscience graduate students (of 6%/year, Figure 5.5; from AGI's 2009 Geoscience Workforce Program study; http://www.agiweb.org/workforce/reports.html). Within a year of the loss of our IT web designer (2004), the department's website was out of date, and graduate student recruiting began to suffer. With the losses of two sedimentary geology faculty, Drs. Dorobek and Willis in 2006, our ability to advise and therefore admit graduate students interested in petroleum geosciences suffered. The combined effect of these setbacks led to graduate enrollments that dropped more quickly than the national trend from 2005 to 2007, until College IT personnel began to improve the department's website and new sedimentary geology faculty, Drs. Tice, Wade, Weiss and Pope were hired (2007-2009). We anticipate continued growth in our graduate petroleum geosciences program with the establishment of the Berg-Hughes Center and arrival of Dr. Mancini in spring, 2010.

The average number of years taken by our M.S. students to complete their graduate studies varies greatly (Figure 6.6) with a mean of about three years. Many of our students take internships with petroleum companies over the summer. While internships provide our petroleum geoscience students with excellent career preparation, students find it challenging to complete their thesis research in a timely manner without dedicating their summers to data collection and writing. We note that some students take extraordinary times to complete their M.S. Theses; yet, some students are able to finish their degrees in two years. The average number of years taken by our Ph.D. students to complete their degrees has come down in recent years (Figure. 6.7), and residence times are now typically five to six years. In some cases, students have continued to register in absentia, without any evidence that progress towards their dissertations has been made; ultimately, University regulations come into play to limit the number of years a student may continue in our program.
Figure 6.5. Graduate Student Enrollments by Degree

Figure 6.6. Years to Complete M.S. Degree, Mean and Standard Deviation
Many of our M.S. candidates are domestic students. The rise in Geology M.S. students corresponds to increases in domestic students and a drop in the percentage of international students from 45 to 40% (Figure 6.8). Of the Department's domestic graduate students, ~10-15% come from under-represented groups (Figure 6.9), which falls short of our goals but is better than the national average in geosciences of ~2% (over 2002-2004; 2009 AGI Geosciences Workforce Program). With 30-37% female graduate students in the Department (Figure 6.10), we also recognize challenges to improve gender parity. Nationwide, 45% and 40% of Masters and Ph.D. degrees in geosciences were conferred to women in 2007 (from the 2009 AGI Geoscience Workforce Program).
In our recruiting efforts, we would like to increase the number of 1) geophysics students, 2) the number of Ph.D. students, and 3) the number of under-represented students, including African America, Hispanic, and women graduate students.
6.8 Student Internships

A significant number of our graduate students take summer internships with petroleum (and environmental) companies. The Department of Geology and Geophysics does not require students to accept internships, as some other departments at TAMU do, but we encourage this form of career preparation. Representatives of many petroleum companies view internships as an excellent opportunity for students to gain industry experience and they facilitate mutual evaluation by the student and company. Summer interns may be involved in a variety of projects, from subsurface mapping, to production geology and reservoir characterization, preparation for drilling or leasing, or working with computer applications. Major oil and gas companies increasingly make offers of full time professional employment only to their top-ranked interns.

In addition to internships that take the student off campus, we have experimented with virtual internships, where companies and student interns collaborate through internet-based tools, and students remain at Texas A&M University. Companies have cited several advantages to the arrangement including limited insurance issues, reduced time spent on managing students, the ability for students to utilize university resources, and the ability to prepare students before organizing formal summer internships. This program was initiated by collaborating with one of our Advisory Council members, Mr. M. Lilly, President of Geo-Watersheds Scientific, a hydrogeology consulting firm in Alaska. Five students have participated in virtual internships with Geo-Watersheds Scientific and ExxonMobil.

6.9 Industry Contributions to Graduate Education

During the period of time that the Department was short of sedimentary geology faculty, we were able to provide an excellent course in sequence stratigraphy (Geol 622; fall, 2007) and a seminar on basin analysis (Geop 681; spring, 2009), thanks to the contributions of Dr. A. Donovan (of BP) and a number of Ph.D. scientists (from Anadarko, BP, Devon, and Marathon). Our graduate programs have also benefited from recent contributions of Chevron, Devon, and Shell to teach special topics graduate field courses (Geol 609) taught in the Book Cliffs, UT and the Permeant Reef of the Guadalupe Mountains, NM and TX. Numerous contributions to the Student AAPG Chapter have made field excursions to the carbonate platforms of the Yucatan and Florida possible.
6.10 Program Assessment and Outcomes

In 2008 the Department initiated a comprehensive program assessment of the goals and outcomes of our graduate degree programs. This process identified several learning goals of our graduate programs, including 1) knowledge of a specific geological discipline, 2) the ability to place that knowledge in a broader geological context, 3) ability to carry out original research, 4) increased levels of research publication and visibility at professional meetings, and 5) strong communication skills. Our assessment process was carried out for the first time during the 2008-2009 academic year. The results may be biased by the relatively small number of students who graduated during that year, as well as a poor response rate to our exit survey (only four of 12 graduating students completed the survey).

Of graduate students surveyed, all obtained employment as professional geologists/geophysicists, or obtained postdoctoral research positions. In addition, 75% held a summer internship during the period that they were enrolled in the graduate program. All graduate students who responded felt that they were well prepared for their careers and they had positive personal experiences as students here.

We are less pleased by the number of publications that resulted from M.S. theses and Ph.D. dissertations. Of the four geology and two geophysics M.S. graduates in 2008-09, none submitted a manuscript before leaving. Two of the geology and one of the geophysics M.S. graduates had made research presentations at professional meetings. Between the two graduating geology Ph.D. students, only one manuscript had been submitted for publication in a peer-reviewed journal, and seven presentations had been made at national meetings. The two geophysics Ph.D. students averaged one manuscript and two research presentations before leaving the program.

Imperial Barrel Contest

In addition to our formal assessment of graduate programs across different geological disciplines, we can evaluate the strength of the department's petroleum geosciences by the students' performance in external competitions. A team of five graduate students competed in the 2009 Imperial Barrel Award Competition sponsored by the American Association of Petroleum Geologists (AAPG). Despite the fact that this was the first year that Texas A&M University participated in this competition, the students won first place in the Gulf Coast Regional Competition (Figure 6.11; April 3, 2009 in Houston) and took fourth place in the International Competition (June 24, 2009 in Denver). Competition problems were designed to simulate industry exploration and development problems. Student teams are presented with geological datasets for a basin and asked to develop prospects leading to drilling recommendations.
6.11 Strengths and Challenges of Graduate Programs

Our formal program assessments and informal observations reveal that we have regained our strength in the graduate petroleum geoscience program. Our students appear to have excellent applied employment opportunities, beginning with summer internships and later, with full-time professional offers. Support of the graduate program is excellent, with significant numbers of teaching assistantships (GATs), research assistantships (GARs), and fellowships. Some of our Ph.D. students have obtained postdoc and academic appointments as college and university faculty. However, we have not met our goals in student-authored publication, and we have not succeeded in recruiting the number of research-oriented Ph.D. students we would like. We hope that our postdoctoral fellows will help us mentor students, and help us establish a culture of student publication. We recognize the need to prepare research proposals to offer more research assistants, which will allow greater numbers of students to focus their efforts on research. The Berg-Hughes Center should be especially helpful in initiating funding for petroleum geoscience research. We also expect that multi-year fellowship offers will help us recruit outstanding new graduate students and give them the time to dedicate themselves to research and publication. A long-term challenge we face is to diversify our graduate students both in terms of under-represented groups and gender.
Chapter 7 - Departmental Research

7.1 Research Strengths of the Department

The Department of Geology and Geophysics has a long-standing reputation in applied petroleum geoscience; in earlier years, the department was known for the education it provided and in later years, graduate geology and geophysics programs became known for directed research in petroleum geology and geophysics. More recently, the Department has invested in developing a strong program in environmental geosciences, which together with University initiatives in water resources and management, represents an emerging research strength. Tectonophysics was introduced as a research focus soon after the Agricultural College of Texas was renamed, and the new University emphasized research. Tectonophysics continues to be an active area of graduate research with funding available from a number of sources. Studies of life and Earth history have long been a focus of the department, with obvious applications of biostratigraphy to petroleum geosciences, but in recent years, investigations of the geologic record have increasingly focused on the history of climate change.

Research strengths of the Department in 1) petroleum geosciences, 2) water resources and environmental geosciences, 3) tectonophysics, deep crust and mantle dynamics, and 4) life, climate and Earth history align well with research funding of NSF, DOE, and the energy industry. The level of our activity in each of these areas is described below, documented by records of publication (Appendix D) and funding (Appendix E). Recognition of faculty expertise in these research areas is indicated by invited talks (Appendix F), editorships, memberships on review panels, and other professional activities (Appendix G).

Petroleum Geosciences

Research initiatives in petroleum geosciences at Texas A&M began in 1965, when Dr. Robert R. Berg, a well-known and respected consultant in the petroleum industry, was named Head of the Geology Department. Dr. Berg hired research-oriented faculty from industry, including Shell Development geologists, Drs. John Handin (and his structural geology research team), Robert Stanton, and Wayne Ahr, and a Shell Development oceanographer, Dr. Richard Rezak. In 1967, Dr. Terry W. Spencer was recruited from his applied seismology position in industry, to build the new Geophysics Department. Over the years, faculty and students of Geology and Geophysics Departments (and later, as members of the merged department) made significant contributions in a number of petroleum geoscience applications, including basin analysis, sequence stratigraphy, geochronology, petrophysics and reservoir characterization, capillary forces and sealing capacity, structural trapping, seismic imaging and analysis of reservoirs. Graduate students have made use of a variety of tools to investigate reservoirs.
Over the eight years reviewed here, the department experienced challenges in hiring an outstanding petroleum geologist, and suffered the loss of two excellent sedimentary geologists, Drs. Dorobek and Willis, to industry positions. While the Department's strengths in petroleum seismology and structural geology were maintained, the petroleum geosciences program lost expertise in basin architecture, and siliciclastic sedimentology and stratigraphy. As a consequence, the department's Graduate Recruiting and Admissions Committee could not make offers to many qualified graduate student applicants with career goals in applied sedimentary geology. In addition, collaborations with members of the Petroleum Engineering Department fell off, and records of publication and funding suffered.

With the addition of excellent new faculty, including Drs. Mancini, Pope, Sun, Tice, and Weiss, we have regained much of the strength we lost in sedimentology, stratigraphy, and petroleum geophysics, with new directions in sediment provenance studies, carbonate reservoirs, organic carbon burial in fine siliciclastics, reservoir geophysics, and dynamic sediment transport modeling. We are confident in the new members of the department, and expect that publication and funding rates in sedimentary geology and petroleum geosciences will increase. More recently, the departure of Dr. John Hopper, one of our reflection seismologists has hurt our petroleum geophysics program. As of this year, a new geophysics faculty position has been approved by the College of Geosciences, and we hope to regain our strength in active-source geophysics and seismic interpretation.

Most recently, the Berg-Hughes Center for Petroleum and Sedimentary Systems has been established to facilitate integrated, multi-disciplinary studies of reservoirs and sedimentary basins, bringing together sedimentologists, stratigraphers, structural geologists, geophysicists, and petroleum engineers. With our industry contacts, we are confident that we can gain access to state-of-the-art datasets. Graduate students have access to computational and imaging facilities in our department to analyze and interpret 3D seismic datasets. High resolution imaging facilities are available to study core, including CT-scanning, SEM, EDS, XRF, CL, NMR. Between the Tectonophysics Laboratory and labs of Petroleum Engineering, petrophysical properties of rocks can be measured, such as elastic P- and S-wave velocities, inelastic compaction behavior, permeabilities, and capillary pressures.

Water Resources and Environmental Geosciences

The Department has strengths in theoretical modeling of subsurface aquifers, in environmental geochemistry and biogeochemistry focused on fate, transport, and biogeochemical behavior of contaminants, in near-surface geophysics adapted to image the upper 30-100 m beneath Earth's surface, and in engineering geology. The research of Dr. H.-B. Zhan and students addresses groundwater flow and solute transport in aquitard-aquifer systems, stream-aquifer interactions, dynamics of horizontal wells and non-Darcian flow and its impact on non-Fickian dispersion of
solute through rigorous, mathematical modeling and analysis. Many of Dr. Zhan's students are part of the university's Water Management and Hydrological Sciences, and they benefit from the perspectives of geoscientists, agricultural scientists, and engineers. However, the Department has tried (and failed) to hire an applied hydrogeologist, who can advise students in hands-on field research.

Environmental geochemistry and biogeochemistry faculty have involved students in a number of studies of contaminants that have inadvertently been introduced into natural systems, including soils and groundwater. Dr. B. Herbert's research addresses the chemistry of organic contaminants at clay and mineral surfaces. Dr. Tice also works in the area of biogeochemistry and adds to strength in this area. However, our environmental geosciences lost when Dr. J. McGuire left the department. To rebuild the environmental geochemistry in this area, we need a field-oriented biogeochemist interested in investigating biological processes and redox reactions in contaminated and natural ecosystems.

The near-surface geophysical research of Dr. M. Everett can be applied to study effects of human activities, such as building, excavating, tunneling and storing or monitoring accidentally released hazardous materials. EM induction and ground penetrating radar are used to image the top 30-100 m beneath Earth's surface. Near-surface geophysics research at Texas A&M University has also found increasing applications in archeological prospecting. Current research includes the development of finite element analysis and inversion techniques for controlled-source electromagnetics, AVO analysis and vector migration of ground-penetrating radar data, archaeological geophysics at historic sites, electromagnetic characterization of fractured rocks, resistivity imaging of unknown bridge foundations, and electromagnetic mapping of deformation structures for meteorite impact hazard assessment.

A number of environmental geoscience problems draw on geomorphology and engineering geology. Geomorphology and engineering geology research of Drs. Giardino and Mathewson address problems associated with geological processes that affect man-made structures as well as natural geohazards.

_Tectonophysics, Deep Crust and Mantle Dynamics_

The Department has research strengths in the study of tectonic processes, both through mechanical analysis and approaches taken by faculty and student associates of the Center for Tectonophysics, and through interdisciplinary geochemical/geophysical approaches taken by a focus group interested in Deep Crust and Mantle Dynamics. Studies of faulting in the upper crust, transitional brittle-ductile deformation at mid-crustal depths and high temperature plastic flow in the lower crust and mantle are investigated at all scales, from atomistic flaws to mesoscale structures to rifts, trenches and mountains formed at plate boundaries. Members of
the Center for Tectonophysics and Deep Crust and Mantle Dynamics group have wide ranging expertise including structural geology, mechanics of materials, mineral physics, geochemistry and petrology, and geophysics. Numerical mechanical analyses and geophysical modeling benefit from state-of-the-art computational facilities. A wide range of mechanical properties measurements can be made in the John Handin Rock Deformation Laboratory, and deformation microstructures and textures can be investigated by optical and electron microscopy. Analytical facilities available to study petrological relations, geochemistry, and defect chemistry include the department's electron microprobe, IR spectrometer, TIMS and ICP-MS mass spectrometers of the Ken Williams Radiogenic Isotope Laboratory, and microanalytical TEM instruments of the university's Microscopy and Imaging Center. With the broad-ranging interests of faculty in tectonic processes, and variety of theoretical, experimental, and analytical capabilities, students may pursue research questions by multiple approaches. Ongoing research includes modeling of dynamic fault rupture, experimental studies of rock friction at high velocities, microstructural studies of San Andreas Fault materials recovered by the SAFOD project, experimental studies of carbonate deformation under conditions of subduction zones, deformation of ultramafics under mantle conditions, geochemical studies of crustal evolution, and petrologic determinations of water fugacity in mantle-derived rocks.

*Life, Climate and Earth History*

Recent hires in the fields of sedimentology, geobiology, paleontology, and geochemistry have supplemented an established faculty to build a program with potential for international prominence in the study of the interaction of the biosphere, ocean, and atmosphere throughout Earth history. Among the faculty interested in this area of research, Drs. Olszewski and Wade are recent recipients of early career awards (the 2009 Schuchert and 2008 Hodson Awards, respectively). This program further benefits from the participation of many faculty, staff scientists and students of the Departments of Atmospheric Sciences, Biology, Oceanography, and Geography, and the Integrated Ocean Drilling Program.

Our studies of ancient environments are complemented and enriched by ongoing research into the physical, geochemical, and faunal record of historic environmental change. We have an important focus on using the fossil record to understand how biological systems responded to ancient environmental and climate changes. Ongoing studies include Late Paleozoic ice ages and Paleogene climate shifts. A currently funded NSF project involves six faculty members in the department integrating biogeography, stratigraphy, and isotopic methods (C, O, Nd) to explore circulation changes in the North American epeiric sea during the onset of the late Paleozoic glaciation.

Studies of climate deterioration and global change in the Cenozoic take advantage of samples from ocean drilling and terrestrial sections from the Gulf States both of which have excellent age
control. The work centers on benthic, nektobenthic, and planktic organisms of shelf environments and the open ocean, providing a bridge between continental and pelagic ocean records. This research is aided by the ongoing biostratigraphic research on calcareous plankton by faculty and graduate students in our department. At the other end of the time scale, faculty and students study the very early history of the Earth, exploring the microbiology and environmental conditions of the Early Precambrian, a time of very large-scale change in climate and environmental conditions of oceans and atmosphere. Recent studies have examined regional and global records of paleobiological, sedimentological, and geochemical change in an attempt to identify spatial and temporal gradients in ancient oceans and climates.

7.2 Research Groups and Centers

Berg-Hughes Center for Petroleum & Sedimentary Systems

With the recent approval of the new Berg-Hughes Center, faculty from our department, and the Departments of Oceanography and Petroleum Engineering have expressed interest in participating in new collaborative research ventures. The Berg-Hughes Center will be an organizational unit of the College of Geosciences, with the purpose of hosting multidisciplinary research that addresses fundamental scientific questions and makes applications to petroleum systems that will benefit Texas and address the nation's energy needs. In addition to its research goals, the center is intended to provide an innovative multidisciplinary education in petroleum and sedimentary geoscience, and contribute to the career development of geoscience and engineering students who work together in joint research projects, and exchange ideas in seminars.

Industry colleagues have expressed their enthusiasm for the Berg-Hughes Center, both by verbal and written communication, and by contributions of funds to establish the Center's endowment. Earnings from endowments will go to student scholarships, fellowships, and undergraduate summer internships. Funding of research will come primarily through external contracts and grants, from the Department of Energy and from industry. Dr. Ernest Mancini will join the Department of Geology and Geophysics in Spring, 2010. He has accepted the challenge of leading the Berg-Hughes Center as its first Director, and he has already prepared proposals to fund its first collaborative research projects. Dr. Mancini, a respected basin-scale stratigrapher, paleontologist, and petroleum geologist, has the support of 18 members of the department who wish to participate in the Center, in addition to the support of faculty from the College of Geosciences and Petroleum Engineering.
Table 7.1. Berg-Hughes Center Faculty Associates in Geology and Geophysics

<table>
<thead>
<tr>
<th>Name</th>
<th>Grossman</th>
<th>Raymond</th>
<th>Wade</th>
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<tr>
<td>Ahr</td>
<td>Bouma</td>
<td>Ikelle</td>
<td>Spang</td>
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<tr>
<td>Fred Chester</td>
<td>Kronenberg</td>
<td>Sun</td>
<td>Wiltschko</td>
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<tr>
<td>Judith Chester</td>
<td>Olszewski</td>
<td>Tice</td>
<td>Yancey</td>
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<td>Gibson</td>
<td>Pope</td>
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The Berg-Hughes Center will be housed in the Halbouty Geosciences Building, but participation is expected from members of the entire College and members of Petroleum Engineering. The center will host seminars and workshops for students and independent oil and gas producers.

Water Resources and Environmental Geosciences

The Department invested in environmental geosciences over the last 12 years, and it now represents one of our strengths. Water resources research and environmental geosciences benefit from colleagues in the College of Geosciences, Engineering and Agriculture with interests in hydrology and environmental studies. The Department has faculty with expertise in theoretical groundwater modeling, environmental geochemistry, geophysical methods, geomorphology, and engineering geology. Numerical models of Dr. H. Zhan are relevant to groundwater flow and solute transport. However, we believe that the department's strength in hydrogeology and the strength of the university's Water Program would benefit by hiring an applied, field-based hydrogeologist. Drs. Herbert, Grossman, Marcantonio, and Tice investigate natural systems by geochemical (and biogeochemical) approaches. The Department has strength in this area of research, but could use replacement of a recent faculty loss (Dr. J. McGuire) by a new faculty member who works on biogeochemical processes in natural systems. This research area benefits greatly from Dr. Everett's near-surface geophysics contributions and from Dr. Giardino's and Dr. Mathewson's geomorphology and engineering geology contributions.

Table 7.2. Water Resources and Environmental Geosciences Faculty

<table>
<thead>
<tr>
<th>Name</th>
<th>Grossman</th>
<th>Marcantonio</th>
<th>Raymond</th>
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<tbody>
<tr>
<td>Everett</td>
<td>Herbert</td>
<td>Mathewson</td>
<td>Tice</td>
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<tr>
<td>Giardino</td>
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<td>Zhan</td>
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Center for Tectonophysics

Faculty, postdoc and student associates of the Center for Tectonophysics evaluate tectonic events and rock deformation by a combination of theoretical analysis, experimentation, and observation that bears on the mechanics that govern faulting, plate tectonics, and mantle flow. Experimental determinations and mathematical modeling of the mechanical behavior and associated deformational processes are employed to understand the structures of mountain belts, plate boundaries, and deformed sedimentary, igneous and metamorphic rocks at all scales of observation. Applications include the development of fractured reservoirs, the transport and storage of fluids in petroleum and hydrological systems, and such fundamental processes as plate rifting, subduction, mantle convection, transform faulting, slow episodic creep, and seismogenesis. Tectonophysics research is also applied to problems in geomechanical engineering. Tectonophysics hosts a well-attended weekly seminar series each spring semester.

Center faculty maintain a healthy level of external funding in support of basic and applied tectonophysics research. Collaboration between faculty within the Center, as well as with researchers elsewhere on campus and from other institutions is common. Recent funding sources include the NSF, USGS, DOD, and DOE, as well as industrial sources including Shell, BP, ExxonMobil, and Hess. Center researchers are involved in a number of national and international research programs and initiatives, including NSF MARGINS, SCEC, IODP-NanTroSEIZE, and EarthScope-SAFOD. Seventeen students are Associates of the Center and two postdoctoral fellows, Drs. Holyoke and Zhong.

Table 7.3. Center for Tectonophysics Faculty Associates and Supporting Faculty

<table>
<thead>
<tr>
<th>Center Associates</th>
<th>Duan</th>
<th>Newman</th>
<th>Wiltschko</th>
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<td>Fred Chester</td>
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<td>Judith Chester</td>
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<th>Supporting Members</th>
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<th>Biscontin (Cven)</th>
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<td>Carlson</td>
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<td>Guillemette</td>
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<th>Spang</th>
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<td>Carlson</td>
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<td>Guillemette</td>
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Deep Crust and Mantle Dynamics

Studies of tectonic and geodynamic processes in the department also draw on interdisciplinary approaches involving geochemistry, petrology, and geophysics. Current projects include EM Imaging of the Earth's deep interior, geochronology of plate collisions, chemical evolution of the crust and mantle, natural deformation microstructures of ultramafic assemblages and inferences of rheology, and planetary dynamics. The group runs a semester-long weekly seminar series on topics in Deep Crust and Mantle Dynamics each year. Members of the Deep Crust and Mantle Dynamics group include members of the Department of Geology and Geophysics as well as faculty in Oceanography and research scientists at IODP:

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<tr>
<th>Table 7.4. Deep Crust and Mantle Dynamics Faculty and Post-docs</th>
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<tr>
<td>Carlson</td>
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<tr>
<td>Everett</td>
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<tr>
<td>Fox</td>
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<tr>
<td>Geldmacher (IODP)</td>
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Geobiology, Paleontology and Climate Change

Much of the Department's strength in Life, Climate, and Earth History draws on faculty members with specialties in geobiology and paleontology. Geobiology is the study of how living things interact with geological systems at present and in the past. Two of its major subdivisions are geomicrobiology and astrobiology. Paleontology, the study of ancient life, takes many of the topics of geobiology and extends them through geological time, addressing how organisms have responded to changes in environment and climate.

We offer rigorous cross-disciplinary education in all these areas to our graduate students. Students can customize their coursework to advance their particular research interests as well as get a broad background in the current issues facing scientists at the frontier between the Earth and life sciences.

Climate change research in our department involves geobiology and paleontology as well as isotope geochemistry and paleoceanography. One specific research focus is how isotope and trace element tracers can be used to understand the relationship between past climate change and past oceanic biological productivity, deep-ocean circulation, and patterns of continental aridity. Another research focus is measuring the geochemistry of microfossils to investigate past sea surface and bottom water temperatures and gain insights into vertical and latitudinal temperature...
gradients. Climate change research is a collaborative effort throughout the College of Geosciences, drawing on members of our department, members of Departments of Atmospheric Sciences, Oceanography, and Geography and the Integrated Ocean Drilling Program (IODP).

| Table 7.5. Life, Climate, and Earth History Faculty in Geology and Geophysics |
|------------------|------------------|-----------------|-----------------|
| Grossman         | Olszewski        | Tice            | Weiss           |
| Marcantonio      | Raymond          | Wade            | Yancey          |

7.3 Research Facilities

The Department has a wide array of laboratories and facilities in support of research, many within the department, and a number that are available to faculty and students as College and University facilities.

Department Laboratories and Instrumentation

Some laboratories within the Department are maintained by individual faculty, but many are shared facilities. Many of the research laboratories are also used for instructional purposes and graduate laboratories. Further details of the laboratories and facilities described here can be found on the Department’s website (http://geoweb.tamu.edu/research-facilities).

Computational Resources. All faculty and most students use desktop and/or laptop personal computers for much of their work, access to the internet and e-mail. In addition, several faculty and faculty groups maintain rack-mounted servers and clusters. Shared computing facilities of the department include several UNIX servers and a cluster of 153 nodes of high performance computing. The nodes consist of Appro 1124i AMD Athlon dual processors operating at 1.5 GHz with 2 GB of memory. The cluster operates under the Rock Clusters Operating System. There are two classrooms populated with individual computers and data analysis software for instructional use. There is also a common computing area on the third floor with computers configured for open access by graduate students, along with a printer and two large-format plotters.

The departmental computer resources are managed by extremely competent and dedicated IT personnel, Steve Tran and Ryan Young, who have managed to satisfy a large population of faculty and students, some with significant computational research programs. However, the department presently lacks sufficient air-conditioned space to properly cool its computers; this
has been a persistent problem over the past few years. We are unable to operate all computational facilities simultaneously (some systems must be shut down to operate others) and we cannot plan any expansions or improvements in computational abilities without addressing this problem. The College of Geosciences has established a new, centralized computational data center and server room in the Oceanography and Meteorology (O&M) Building and offered to provide space in this center for the department's computer clusters. However, the TAMU CIS cable between the Halbouty and O&M Buildings is not a dedicated line, and most geology and geophysics faculty have decided to maintain their systems within easy reach in the Halbouty Geosciences Building.

**Earthquake Simulation Lab.** The Earthquake Simulation Lab conducts numerical simulations of past earthquakes and future scenario earthquakes. The lab facilities include a Sun Fire X4600 server with 8 processors, 48 GB memory and 450 GB hard disk, a Sun Ultra 40 workstation with 2 processors, 8 GB memory and 5 TB hard disk, and several high-level PC systems. The lab has access to a 52-node 832-processor IBM Cluster 1600 system - Hydra of the Texas A&M Supercomputing Facility.

**Computing and GIS Remote Sensing.** The Geology and Geophysics Department provides Geographic Information System (GIS), Trimble Global Positioning System (GPS) receivers, remote sensing, and 3D modeling resources for faculty and students. ArcInfo, ArcView, ERDAS, ENVI/IDL, and WMS are installed and used for research and teaching. The computer lab (Halb 308) is used for compiling and digitizing spatial and attribute data, interpreting geologic and geophysical data to produce publication-quality maps and diagrams. Eight PC's are equipped with GIS and remote sensing software and field laptops are available with the GPS receivers. 3D visualization and modeling are available in the Immersive Visualization Center, which is a university facility located in the Halbouty Geosciences building. GPS receivers are used to teach Geol 352.

**Near-Surface Geophysics Instrumentation.** A Near-Surface Applied Geophysics Laboratory is maintained in the department by Dr. M. Everett. Geophysical equipment includes electromagnetic induction instruments (Geonics PROTEM 47, EM34—3, EM31 and EM63), ground-penetrating radar (Sensors and Software PulseEkko 25, 100 and 200 MHz systems), an 8-channel 56-electrode resistivity and 28-electrode induced polarization system (Advanced Geosciences Inc. SuperSting R8/IP), a cesium vapor magnetic gradiometer (Geometrics G - 858), gravimeter (LaCoste & Romberg), and reflection/refraction seismic equipment (Geometrics StrataView 48-channel seismograph with 14/40 Hz geophones and GeoStuff roll - along capability). Trimble GPS units are available for field geophysics experiments as is a traditional Topcon/Sokkia total-station navigation system and commercial software (seismic/GPR
interpretation includes Kingdom Suite and ProMax). A fully ruggedized Panasonic Toughbook and 30 laptops are also available. This equipment is used to teach Geop 413 and Geop 435.

**Electron Microprobe Laboratory.** The department operates an Electron Microprobe Laboratory for broad-spectrum quantitative compositional analyses, which is heavily used by faculty and students of the department, as well as researchers in Oceanography, IODP, and departments across campus, particularly from several engineering departments and Departments of Physics and Chemistry ([http://geoweb.tamu.edu/RRresearch/probe/Probe_WebPage.html](http://geoweb.tamu.edu/RRresearch/probe/Probe_WebPage.html)). The Cameca SX50 is equipped with 4 wavelength-dispersive X-ray spectrometers, SEM capability, PGT energy-dispersive X-ray system (for EDS) and cathodoluminescence (CL) detector. The microprobe is programmable for overnight analyses and element mapping. The microprobe is used by qualified student and faculty users (289 students and 119 faculty, leading to 122 peer-reviewed publications) and it is used each year in graduate courses (Geol 643 and Geol 665). The success of this Electron Microprobe facility is largely due to its operation and maintenance by our Associate Research Professor, Dr. R. Guillemette, whose experience, expertise, and dedication are recognized by users across campus. Funds to support Dr. Guillemette's salary, the probe's service contract, and software upgrades have largely been provided by the department and user fees. The Cameca SX50 is now 20 years old and we have submitted a $1.2M NSF MRI proposal to replace it with a new, state-of-the-art instrument made by either Cameca or JEOL.

**Environmental Geochemistry Lab.** The environmental geochemistry lab includes instrumentation to characterize metals, nutrients, and trace organics in water, soils, sediments and consolidated rock. Specific instruments include a SpectrAA.200 Varian UltrAA with flame or Graphite furnace, Coy Anaerobic Chamber, Varian 4000 Ion Trap GC/MS/MS, Dionex Ion Chromatograph with a CD 25 conductivity detector, GP50 Gradient Pump and AS40 Automated Sampler, Agilent 6890 Series Gas Chromatograph with autosampler and flame ionization detector, Vario EL III (Elemental Analyzer), Agilent Capillary Electrophoresis, Sartorius CP2P Microbalance, Jenway 6200 Fluorimeter, Metrohm 746 VA Trace Analyzer Ion Analysis (voltametry), and Hitachi V-3010 UV/VIS Spectrophotometer. Faculty and students also have access to the IR Spectroscopy Laboratory.

**Mobile Drill Rig.** A mobile drill rig (B-53) is available to drill with hollow-stem augers to 100 m, or with drilling mud to 300 m, subject to hiring a qualified drilling technician. This rig has been used to drill shallow boreholes and install ground water monitoring wells, but it is in need of maintenance before it can be used again.

**John Handin Rock Deformation Lab.** The Handin Laboratory provides facilities to investigate the deformation of rocks and minerals under controlled conditions appropriate to the
environments of the upper crust to the lithospheric mantle (http://geoweb.tamu.edu/tectono/facilities/john-w-handin-laboratory). The laboratory is equipped with groups of different rock deformation apparatus, devices for measuring physical properties, controlled environment chambers, a rock repository, sample preparation equipment, and a machine shop. Graduate students, visiting scientists, research scientists, and faculty use the laboratory for research and teaching activities. The Handin Laboratory plays a key role in the laboratory component of the graduate core-curriculum courses of the Center for Tectonophysics (Geop 615, Experimental Rock Deformation) and of the Geophysics Ph.D. program (Geop 660, Physics of the Earth's Interior). It is available for research by all qualified faculty and student users of the Center for Tectonophysics.

**Electrohydraulic Loading Facility.** Three loading frames are available for testing rock at elevated temperature and pressure appropriate to upper and lower crust conditions, and at displacement rates up to 1 m/s. The servo-controlled machines are particularly well suited for investigating complex load paths. The facility is currently being upgraded with a new hydraulic pressure generating pump, cooling system, and low-pressure hydraulic, water and air plumbing. In addition, new safety enclosures, high pressure plumbing, electronics for control and data acquisition, and other ancillary equipment will be installed. This facility houses:

- A 500-ton servo-controlled, electrohydraulic testing machine (MTS load frame) capable of deforming 2.5 by 6 cm cylindrical specimens in triaxial compression under controlled loading/deformation histories. Originally designed with an argon gas pressure vessel to reach confining pressures and liquid pore fluid pressures of 1200 MPa and temperatures to 1200 C this apparatus may be used with other pressure vessels to deform larger samples at lower pressures and temperatures.
- A 150-ton servo-controlled, electrohydraulic testing machine (MTS load frame) capable of deforming samples up to 2.5 cm diameter under confining pressures to 300 MPa, pore fluid pressures to 200 MPa, and temperatures to 300 C. The pore-fluid pressure system may be used in a flow-through or single-ended oscillating pressure mode to determine fluid flow and storage properties during deformation, and is ideal for the investigation of the mechanical behavior of both crystalline and sedimentary rocks in geothermal and petroleum-gas reservoirs.
- Bi-axial load frame, with 150-ton servo-controlled load capability on each axis, that is capable of achieving medium strain rates (7 cm displacement at a rate of 1 m/s). This apparatus is being constructed from two load frames that were earlier designated as the MSR and HTR. This apparatus will be used for high speed friction studies; it also may be fitted with other pressure vessels or sample grips to permit true-triaxial tests and high-speed fracture tests.
High Pressure and Temperature Deformation Facility. Five rock deformation machines are available for testing ductile deformation of rocks and minerals at pressures of the middle crust to upper mantle. These apparatus deform cylindrical samples at constant strain rate and are capable of constant stress loading with some modification. The facility includes the following apparatus:

- Two Heard-type, triaxial argon gas apparatus for deformation of 1 by 2 cm cylindrical specimens at confining pressures to 500 and 1000 MPa (and pore pressures to 200 MPa), temperatures to 1000 C and strain rates from $10^{-3}$ to $10^{-8}$ sec$^{-1}$. One of these apparatus is in current use and the other requires installation. Pressure and temperature are servo-controlled and stresses are determined from internal load cell readings.
- Two Griggs-Blacic triaxial piston-cylinder apparatus capable of employing weak solid or molten salt confining media for deformation of 6 by 15 mm specimens at confining pressures to 2000 MPa, temperatures to 1300 C, and strain rates from $10^{-3}$ to $10^{-8}$ sec$^{-1}$.
- Griggs, solid-pressure-medium, multiple anvil "cubic" apparatus capable of confining pressures to 7000 MPa and temperatures to 1000 C. This apparatus has been used in Geop 660 to measure P- and S-wave velocities at high pressure and room temperature.

Sediment and Sedimentary Rock Testing Facility. This facility contains several gear driven, triaxial apparatus designed to test mechanical properties of uncemented, granular aggregates and weak rocks at upper crustal conditions. These deformation machines are capable of constant strain rate loading to low rates, and can accommodate large samples.

- Two 10-ton, Heard-type variable strain-rate, triaxial systems (VSR) for deformation of 2 by 4 cm specimens at confining and pore pressures to 300 MPa, externally heated to 300 C and strain rates from $10^{-3}$ to $10^{-8}$ sec$^{-1}$. These apparatus employ internal load cells for sensitive and accurate measurement of force. One system retains the original metal packings for higher pressure work; the other system is fitted with a large-diameter piston and o-ring packings for experiments on weak rocks, sands, and marine sediments at confining pressures less than 120 MPa. This apparatus is ideal for long-term tests of creep consolidation and fluid flow properties.
- Two 100-ton, variable strain-rate, triaxial compression systems (Handin-Logan LSR-type) for deforming 10 by 20 cm cylindrical specimens at confining and pore pressure to 70 MPa, temperatures to 150 C, and strain rates from $10^{-3}$ to $10^{-9}$ sec$^{-1}$. These machines have been used for investigating creep of rock salt. An additional pressure vessel is available for tests on 5 by 10 cm cylindrical specimens in these load frames.
- A 200-ton, variable strain-rate, triaxial-compression apparatus (Handin-Logan LSR) for tests on specimens up to 5 cm diameter and 20 cm length at strain rates from $10^{-3}$ to $10^{-8}$ sec$^{-1}$ at confining and pore-fluid pressures to 300 MPa at room temperature. The apparatus has accommodated studies of acoustic emission, permeability using the...
transient-pulse technique, fracture under mixed tensile and compressive stress states, rock and simulated gouge friction, failure in thick-walled hollow cylinders, and fracture and folding in rock models. After over 6500 experiments, the pressure vessel of this apparatus failed; it has been decommissioned (spring 2009) and will be replaced in the future.

**Petrophysics Facility.** This facility contains two machines to test petrophysical properties under isotropic loading conditions.

- An Autoclave apparatus designed to measure elastic P- and S-wave velocities using piezoelectric transducers with pulse or other signal generators at confining pressures and pore-fluid pressures to 300 MPa.
- An apparatus designed by T. Shimamoto to measure porosity and permeability to pressures of 200 MPa using displaced gas, gas and liquid flow-through capability, and double-ended pressure-decay testing system.

Additional facilities available in the Handin Laboratory

- Digital data acquisition and Computer Equipment: Several mobile, networked PCs each having a Data Translation high-speed, high resolution A/D acquisition board, HP VEE with DT VPI or LabView acquisition software, and a large UPS.
- Acoustic emission recording and counting system.
- Laser profilometer to measure surface geometry.
- Controlled humidity chamber and several furnaces.
- Multiple vacuum and pressure epoxy impregnation systems, curing ovens, and fume hood.
- Diamond coring, diamond cut-off saws, surface grinder for preparation of specimens.
- A machine shop and electronics laboratory containing an assortment of machining equipment (e.g., lathes, mills, drill press, band saw), and electronic fabrication and testing supplies and equipment.

**Friedman Microscopy Lab.** The Mel Friedman Petrofabrics Laboratory is dedicated to the study of deformation textures of naturally and experimentally deformed rocks. The laboratory includes a Zeiss Axioimager A1 Advanced upright research microscope that is equipped with an Axiocam HR and AxioVision4 software for high resolution digital imaging. The laboratory houses five additional research-quality microscopes, and three older Leitz microscopes dedicated to universal stage applications. Equipment for sample cutting, preparation, and polishing is available in a neighboring laboratory. In addition, a photoelastic load frame and heated deformation stage are available to investigate the nature of stress concentrations associated with flaws and geometric irregularities, and to study intracrystalline plastic deformation and recovery.
processes. The facilities in the Mel Friedman laboratory support teaching and research activities in the Center for Tectonophysics. It is routinely used in the laboratory component of Geol 665 (Structural Petrology), which is one of the core courses of the Center for Tectonophysics and the Petroleum Certificate Program.

**Hydrothermal Geochemistry Lab.** This laboratory includes five large-volume, flow-through hydrothermal systems capable of controlled long-term (12+ month) experiments at T = 200 °C, confining and pore-fluid pressures P = 100 MPa and constant fluid flow rates. All wetted parts subjected to elevated temperatures are constructed of materials (including titanium, Hastelloy C-276, Inconel, gold, or teflon) that are inert to most dissolved species. Volumetric strain can be measured while simultaneously monitoring changes in fluid chemistry. The laboratory is also equipped with eight standard, cold-seal pressure vessels and four rapid-quench vessels, and supporting equipment capable of temperatures to 800 °C and pressures to 200 MPa.

**Fluid Inclusion Lab.** The Fluid Inclusion Laboratory at Texas A&M University is equipped with a modified USGS heating and freezing stage, designed by Fluid Inc. USA. This equipment is designed to pass heated air or nitrogen over the sample, permits heating of inclusions to 700 °C. By passing nitrogen gas through liquid nitrogen and then over the sample, inclusions (3-50 μm) can be cooled to -190 °C.

**X-ray Diffraction Lab.** This laboratory houses a Rigaku powder diffractometer with two goniometers. The lab is under the supervision of Drs. Popp and Guillemette and an undergraduate student worker oversees routine operation. This instrument is over 20 years old but continues to function dependably.

**IR Spectroscopy Lab.** The IR Spectroscopy Laboratory is a shared facility of the department with faculty and student users who are engaged in environmental geosciences, tectonophysics and studies of deep crust and mantle processes. This lab houses a Nicolet Magna 560 FTIR with two room-temperature detectors spanning wavenumbers from IR to the near-IR, a high contrast IR polarizer, a NicPlan IR Microscope with polarizer and a high sensitivity, low temperature detector. Transmission and reflection spectra are gathered for large single crystal and powder samples with room temperature and cryogenic specimen holders, a Gemini dual attenuated total reflectance and diffuse reflectance accessory on the main spectrometer bench. Transmission and reflection spectra can be collected for small samples using the IR microscope. The laboratory includes a press to prepare powder samples, diluted by KBr or other salt, and polishing facilities to prepare single crystals for transmission measurements. While the Nicolet spectrometer is now an aging instrument, it continues to provide quality IR spectra and serves our multiple purposes well. Reflection spectra have been collected for contaminated soils, polarized transmission
spectra have been measured for hydrous minerals, and trace hydrogen defects (from ppm down to 40 ppb) have been detected and quantified in nominally anhydrous minerals.

**Sedimentary Geology Lab.** This laboratory is currently being rebuilt, to accommodate new faculty and student research in sedimentary and petroleum geology, as part of the Berg-Hughes Center. A sample preparation lab contains multiple rock saws (oil and water-based), standard and Isomet wafer-blade saws, and two polishing wheels. Four laboratories are available for wet chemistry. Microscopy facilities include two research-grade microscopes with Image Analysis Software, and a Technosyn 8200 MKII Cathodoluminescence Stage with epifluorescence capabilities attached to a Digital Camera and Image Analysis Software. The sedimentary geology lab also houses the Berg Sedimentary Core Teaching Collection. We also have a state-of-the-art Subsurface Computer Laboratory supported by the petroleum industry that includes 14 UNIX workstations and 3 PC workstations. Software includes Geoframes, Geographix, Landmark unix-based software (OpenWorks, Promax, etc.), Kingdom, and Petrel.

**Paleobiology Lab and Collections.** The paleobiology lab facilities include equipment for processing, preparation and microscopic imaging of samples for research in the fields of biostratigraphy, paloeclimater and systematics. Separate rooms are available for microfossil and macrofossil processing, from unconsolidated and indurated sediments. Equipment is available for trimming rocks, size screening and acid preparation, and room is available to organize and work with sedimentary rocks. A dedicated micropaleontology room houses several research-grade optical microscopes. Electron microscopy is done at the University's centralized Microscopy and Imaging Center. A large collections room is maintained with macrofossil samples and continental outcrop samples. These collections complement deep-sea cores stored in the on-campus IODP core repository.

**Evolutionary Geobiology Lab.** This new laboratory supports the research of Dr. Tice and co-workers. It is equipped with standard equipment for culturing and working with microbes, including incubators, freezers, walk-in cold storage, a PCR thermal cycler and gel imaging system, centrifuges, a fluorescence/petrographic microscope, a laminar flow hood and two fume hoods, an anaerobic glovebox, and two large phototroph incubators. This lab houses a Horiba XGT-7000 X-ray fluorescence microanalyzer, capable of semiquantitative and quantitative imaging of the distributions of elements from Na to U on samples up to 10 cm x 10 cm with a spot size of 10 or 100 µm and detection limits to a few ppm.

**Office Espresso Facility.** Faculty, staff, and students have access to a 1.2kW Expobar Pulser Espresso machine capable of 96°C and 0.4 MPa for high resolution and concentration.
In addition to departmental laboratories and facilities, faculty and students have access to several state-of-the-art facilities that have recently been established in the College of Geosciences. These include a new Stable Isotopes Laboratory that combines instruments from laboratories that used to function separately in the Departments of Geology and Geophysics, Oceanography, and Geography. Combining resources of faculty start-up, a successful NSF MRI proposal, and the generous donation of Mr. R. Ken Williams ’45, the College has established a state-of-the-art radiogenic isotope geosciences laboratory in support of faculty and students of our department and others. The College obtained a new XRF core scanner, which is housed in the on-campus IODP facility, which is available to our geology faculty and students. These facilities go a long way to address inadequacies in analytical laboratories identified in our 2002 External Review.

Stable Isotope Lab

The Stable Isotope Geosciences Facility (SIGF) is a multi-investigator, college-wide facility for light stable isotope analyses and science (http://stableisotope.tamu.edu/). The laboratory is managed by an Executive Committee consisting of Dr. E. Grossman (Geol and Geop), Dr. B. Roark (Director, Geog), and Dr. N. Slowey (Ocng), and operated by Laboratory Manager Art Kasson. The SIGF houses three isotope ratio mass spectrometers and four peripheral devices for automated H, C, N, and O isotopic analyses of minerals, waters, and organic matter. This instrumentation is located in two laboratories in the Eller O&M Building. There are currently three faculty members, five graduate students, and three undergraduate students working in the SIGF. The user base includes 22 TAMU faculty members and staff scientists from five departments, three colleges, and the Integrated Ocean Drilling Program (IODP). The facility also serves as the focal point for graduate courses in several departments, including Geol 648 (Stable Isotope Geochemistry). It will shortly host the ISOGEOCHEM listserve, which promotes the exchange of news and information among those with interests in stable isotope geochemistry. ISOGEOCHEM has approximately 1700 subscribers and the website gets 1500-2000 hits per day from approximately 50 countries worldwide.

Ken Williams Radiogenic Isotope Geosciences Lab

The R. Ken Williams ’45 Radiogenic Isotope Geosciences Laboratory at Texas A&M is a 1550 ft² laboratory complex, completed in September, 2008, which consists of a designated perchloric acid fume hood room, gown-up room, dilution and weighing room, clean general chemistry room and ultra-clean chemistry room (http://geosciences.tamu.edu/research/research-facilities/radiogenics). The general chemistry laboratory is designed to class 10,000 clean-room standards, and tests at less than 2000 particles >0.3 μm per ft³ of air. This laboratory includes five clean-air workstations, each testing to better than 100 particles >0.3 μm per ft³ air, and one recirculating laminar-flow workstation (no particle detected). The ultra-clean laboratory, designed to Class 100 specifications, tests to better than 80
particles >0.3 μm per ft³ air. The instrument room houses a Triton thermal-ionization mass spectrometer and an Element XR high-resolution inductively-coupled plasma mass spectrometer. An excimer laser-ablation system is scheduled to be installed this spring semester. The radiogenic isotope geochemistry facilities also include separate rooms for dirty/wet sample preparation, rock crushing, and mineral separation.

The general chemistry lab is used primarily for sample digestion, chemical separation, and elemental purification for Nd-Sm, Sr, and common Pb isotopes from whole-rock powders, microfossils, macrofossil fragments, and rock glass. Common Pb separation is done on anion resin using HBr-HCl chemistry. Bulk REE are separated using EiChrom REE-specific resin and Nd-Sm purification is conducted using reverse-phase chromatography on anion resin and α-HIBA chemistry. Separation and purification of Sr uses EiChrom Sr-specific resin. All clean sample preparation and separation chemistry for U-Pb dating is conducted in the Class 100 ultra-clean laboratory. Our U-Pb zircon geochronology protocol largely follows the annealing, chemical abrasion, and thermal-ionization mass spectrometry (CA-TIMS) methods described by Mattinson (2005). This method has proven highly successful in minimizing U-Pb discordance caused by Pb-loss from radiation damaged zones within the zircon crystal (e.g., Mundil et al., 2004). Total procedural blanks for U-Pb analyses are consistently around 2 picograms Pb per sample. With freshly distilled reagents and carefully prepared samples, however, we have achieved analyses with <1 picogram of total common Pb.

The ThermoFisher Triton thermal-ionization mass spectrometer (TIMS) was commissioned in October, 2008. This instrument is equipped with a retarding-potential-quadrupole (RPQ) energy filter and a modified (14-dynode) MassCom secondary electron multiplier (SEM). Abundance sensitivity and Faraday/SEM ion yield with the RPQ disengaged are 3.9 ppm and 94.5%, respectively and with the RPQ active are 0.006 ppm and 93.3%, respectively. The response of the SEM is linear up to 700,000 counts/sec. The Triton met installation specifications with 2 ppm (1σ) external reproducibility on ¹⁴３Nd/¹⁴⁴Nd for both the La Jolla (0.5118455 ± 0.0000011) and JNd (0.5121014 ± 0.0000007) Nd isotopic standards using 300 nanogram loads and analyzed in static-Faraday mode with amplifier rotation. Subsequent Nd standards run by all operators indicate ~15 ppm (1σ) external reproducibility, but careful loading and analysis by a single operator has produced more consistent results. External reproducibility of Sr isotope standard NIST 987 (0.710243 ± 0.000011) is ~16 ppm (1σ) for all users since installation. Repeat analyses of EarthTime synthetic U-Pb standards yield 100.23 ± 0.13 Ma for the 100 Ma (nominal) standard, 500.18 ± 0.44 Ma for the 500 Ma (nominal) standard, and 2000.6 ± 0.7 Ma for the 2Ga (nominal) standard; all individual analyses are within error of the ages obtained from these standards in three well-established laboratories using the EarthTime double-Pb spike.
The ThermoFisher Element XR inductively-coupled-plasma mass spectrometer (ICP-MS) was funded through a NSF MRI grant and commissioned in February 2009. This instrument is equipped with a secondary electron multiplier, that can be used in ion counting (<3\times10^6 \text{cps}) and analog (3\times10^6 – 10^9 \text{cps}) modes, and with a faraday detector (10^9 to 10^{12} \text{cps}). The dynamic range of the instrument spans five orders of magnitude for 1 ms sample times. The instrument operates at three mass resolutions, ~330, 4500, and 11,600. The dark noise in ion counting mode is less than 0.1 cps. The usual sensitivity of the instrument using a Meinhard concentric self-aspiration nebulizer is better than 10^6 \text{cps per ppb of In}. The short-term (10-minute) stability of the signal intensity is approximately 0.06%, while the long-term (1-hr) stability is approximately 0.6%. Major and trace element analyses generally yield external reproducibilities of approximately 0.5%. Analyses of \(^{206}\text{Pb}/^{207}\text{Pb}, \(^{206}\text{Pb}/^{208}\text{Pb}, \(^{234}\text{U}/^{238}\text{U}\) isotope ratios on NIST standards (981 and U500) are reproducible to within 0.1%.

**XRF Scanner.** A 3rd generation Avaatech XRF core scanner (http://odases.tamu.edu/lab/xrf/) has been installed (June, 2009) at the IODP gulf Coast Repository, on campus, for the purpose of non-destructive multi-element chemical analyses of split IODP sediment cores. This instrument was acquired as part of the university's Ocean Drilling and Sustainable Earth Sciences (ODASES) initiative, in support of IODP research and of ODASES faculty and their students. All four departments of the College of Geosciences have faculty members involved in the program. The XRF scanner irradiates the geologic material with X-rays produced by a 100 watt Rh-anode X-ray tube and detects the excited X-ray fluorescence with a Canberra multichannel analyzer. Elements between Mg and U can be measured in a wide range of geologic materials. The step size between measurements is analyst-controlled and can be spaced as little as 0.1 mm between each analysis.

**University Shared Facilities**

Geology and geophysics faculty and students have access to a number of University-sponsored facilities and labs of other departments. Three facilities are described that we have used in recent years.

**Microscopy and Imaging Center.** With the exception of electron imaging capabilities of the department's Electron Microprobe, all electron microscopy is done at Texas A&M University's central Microscopy and Imaging Center (http://microscopy.tamu.edu). The Microscopy and Imaging Center (MIC) hosts a number of high-resolution electron microscopes, employs qualified technicians and electron microscope specialists in support of research and teaching, and maintains instrument service contracts. Students can enroll in courses taught through the Center in basic and specialized methods of electron microscopy. Geology faculty and students have access to three scanning electron microscopes (SEM), including a conventional JEOL 6400 SEM
and an Electroscan environmental SEM. The MIC’s high resolution scanning instrument is a FEI Quanta 600 field emission SEM with SE (resolution up to 1.2 nm), BSE, EDS, full color CL, and X-ray mapping and digital capture capabilities. This instrument has EBSD and orientation contrast capabilities using HKL/Oxford software.

The MIC maintains three transmission electron microscopes (TEM), of which two are high-resolution, 200kV microscopes. The Jeol 2010 has a point resolution of 0.23nm, and is capable of EDS micro-chemical analysis, convergent-beam diffraction, and nanobeam diffraction. Sample holders include single- and double-tilt stages, one made of Be to optimize EDS analysis, and a heating stage. Image capture is by photographic plate or digital CCD camera. A FEI Tecnai G2F20 field emission TEM has recently been acquired with a point resolution of 0.27 nm, and STEM, EDS, and EELS, and mapping capabilities. This instrument has single tilt, double tilt, and cryogenic specimen holders, and digital imaging.

In addition to electron microscopes, the MIC maintains a confocal light microscope with 6 color lasers for high-resolution epifluorescent imaging, which faculty and students of our department have access to, but have yet to explore.

While there are many advantages to Texas A&M operating a centralized electron microscopy facility, we find it convenient to prepare samples in-house. Equipment in the Halbouty Geosciences Building used to prepare samples for electron microscopy includes conventional saws, grinding and polishing facilities, as well as a LADD carbon coater. A Buehler vibratory polisher is used for the final, chemical polish of samples for SEM EBSD, and a Gatan dual ion mill is used for final preparation of TEM samples.

X-ray Scanner and Computed Tomography. Geology faculty and students are able to acquire X-ray CT images in the Imaging laboratory of the Harold Vance Department of Petroleum Engineering using a Universal Systems hd-350e high resolution X-ray CT scanner. This instrument is managed by Dr. Schechter, Professor of Petroleum Engineering, who has offered members of our department access to obtain nondestructive 3D images of the internal structure of opaque solids. This facility is commonly used to measure porosity, saturations, and a fault rock structure in cores, and to perform enhanced oil recovery flood experiments.

3-D Visualization Lab. The Immersive Visualization Facility in room 260 of the Halbouty Geosciences Building provides advanced 3D visualization for all TAMU researchers using a semi-rigid, rear projected, curved screen. The IVF facilitates imaging large datasets. The screen is 7 m long and 3 m high and is driven by a Dell Precision 690 workstation running Linux. The IVF is operated by the Texas A&M Institute for Scientific Computation.
7.4 Research Publications

With over 30 faculty in the Department of Geology & Geophysics, research interests are broad and varied. However, there are a number of research themes that bring us together into research collaborations. Drawing on publications over the period 2002-2009 (*Appendix D*), we can determine the level of research activity in each of the department's strengths: 1) petroleum geosciences, 2) environmental geosciences, 3) tectonophysics and deep crust and mantle dynamics, and 4) life, climate, and Earth history (*Table 7.6*). The total number of peer-reviewed publications of the department is 430 over the eight-year period.

On the basis of research publications, three of the four areas we identify as research strengths are highly productive, with well over 100 publications in each area. The relatively smaller number of research publications in petroleum geosciences (45) is understandable since we lost several key faculty members of this group and did not replace them for several years of the review period 2002-2009. Remarkably, despite the loss of faculty in petroleum geoscience, this is the research focus that drew the largest number (60) of M.S. students. With recent additions of sedimentary geology faculty with research interests in applied petroleum geosciences, and the establishment of the Berg-Hughes Center, we expect that the rate of publications in this area will soon increase.
### Table 7.6. Faculty, Graduate Students, and Refereed Research Publications in Geology and Geophysics over 2002-2009

<table>
<thead>
<tr>
<th>Faculty</th>
<th>MS</th>
<th>PhD</th>
<th>Pubs</th>
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<tbody>
<tr>
<td><strong>Petroleum Geosciences</strong></td>
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</tr>
<tr>
<td><strong>Primary:</strong> Ahr (sedimentology), Dorobek (stratigraphy), Gibson</td>
<td>60</td>
<td>26</td>
<td>45</td>
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<tr>
<td><strong>Primary:</strong> Ikelle (geophysics), Pope (sedimentology), Spang</td>
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<tr>
<td><strong>Primary:</strong> Sun (geophysics), Willis</td>
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<tr>
<td><strong>Secondary:</strong> Grossman (geochemistry), Tice (sedimentology), Wiltschko</td>
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<td></td>
<td></td>
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<tr>
<td><strong>Secondary:</strong> Kronenberg (geophysics), Blasingame (petroleum eng.),</td>
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<tr>
<td><strong>Secondary:</strong> Bouma (sedimentology).</td>
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<tr>
<td><strong>Water Resources and Environmental Geosciences</strong></td>
<td>51</td>
<td>40</td>
<td>141</td>
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<tr>
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<td><strong>Primary:</strong> Mathewson (engineering geo), Zhan (hydrogeology).</td>
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<tr>
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<tr>
<td><strong>Secondary:</strong> Grossman (geochemistry), Tice (geobiology), Sparks</td>
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<tr>
<td><strong>Secondary:</strong> Richardson (oceanography), Tchakerian (geomorphology),</td>
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<tr>
<td><strong>Secondary:</strong> McGuire (geochemistry), Vitek (geomorphology).</td>
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<tr>
<td><strong>Tectonic, Deep Crust and Mantle Dynamics</strong></td>
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<td>10</td>
<td>135</td>
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<tr>
<td><strong>Life, Climate and Earth History</strong></td>
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<td>109</td>
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<tr>
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<tr>
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<tr>
<td><strong>Secondary:</strong> (sedimentology).</td>
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</table>

1. The primary and secondary associations of each faculty member in the different research themes are indicated.
2. Total number of MS students including current students, 2002-2009.
3. Total number of PhD students including current students, 2002-2009.
4. Total number of publications attributed to each research theme, 2002-2009. There were 10 publications in geoscience education over this time period.
5. Former faculty not associated with TAMU at this time.
6. Joint faculty.
7. Adjunct faculty.
8. Faculty Emeriti.
9. One Ph.D Student accepted a tenure-track position at a university.
10. Nine Ph.D Students accepted tenure-track positions at universities.
7.5 Research Grants and Contracts

Sources of Research Funding

Research activity in the department can also be evaluated by looking at the level of research funding through grants and contracts (Appendix E). While the sources and levels of funding differ among the different research themes of the department, we anticipate increases in funding, in coming years, in each of the four areas of departmental strength.

Petroleum geosciences have largely been supported by U.S. DOE grants and contracts, industry contributions to individual faculty and industrial associates programs such as the Consortium for Automated Seismic Processing (CASP), with some funds coming from PRF and international funds such as Sinopac (China Petroleum and Chemical Corporation) and Qatar Petroleum Research Program. Funding is expected to rise substantially with the initiation of the Berg-Hughes Center for Petroleum and Sedimentary Systems, corresponding to the development of new industrial research consortia, and new DOE and PRF research initiatives.

NSF funding is important to all other areas of departmental research. In addition to NSF grants, environmental research in the department has been supported by DOE, TTI, and USDA projects. Tectonophysics research has been supported through grants from the USGS, DOE, DOD, with significant NSF funding coming from dedicated Margins, SCEC, and SAFOD initiatives. Life, Climate, and Earth History research of department faculty of Geology and Geophysics (adloc and joint) has been supported by both EAR and OCE panels of NSF and by the NSF CHRONOS project. The department has also attracted funding through an NSF-CAREER grant awarded to Dr. Wade and NSF educational research and innovation funding of Dr. Herbert.

Twenty-one faculty members of the Department of Geology and Geophysics have been first PIs on active, externally-funded projects, representing 66% of the faculty as a whole (using the current number of FTE faculty, 32 in FY 2009). Research expenditures have increased in recent years from $704K in fiscal year 2004-2005 (FY05) to $1,768K in fiscal year 2008-2009 (FY09), including TAMRF, TEES, and TAMU-RS accounts. This rise has been more than linear with annual increases from FY05 to FY09 of 6.5%, 4.0%, 26%, and 79%. One of the reasons for this increase is the number of proposals our active young faculty typically prepare and submit each year. 85% of the department's Assistant and Associate Professors serve as first PIs. Fewer (47%) full Professors had research expenditures as first PIs during FY09; however, in a number of cases, full Professors served as secondary PIs to projects with junior faculty as first PIs.

Lastly, half the faculty members and all of the Assistant Professors are PI or co-PI on at least one NSF grant. New research projects of junior faculty include studies of reservoir geophysics, sediment transport by tsunamis, earthquake rupture dynamics, mantle processes, the geochronology of tectonic events, Cenozoic climate and productivity, Paleozoic paleoecology,
and Precambiran biogeology. Department of Geology and Geophysics faculty have been successful in building the College of Geosciences facilities in stable and radiogenic isotope geochemistry, with two successful NSF MRI proposals during the review period.

External Research Collaborations

With the increasing challenges posed by unsolved scientific problems, and the realization that research breakthroughs often take interdisciplinary approaches, many of our faculty engage in research collaborations that lead to multi-authored papers and research projects with multiple principal investigators. The extent of research collaboration by faculty with others in the department is illustrated in Table 7.7, along with collaborations with faculty of other departments, research scientists of IODP, and researchers at other universities, colleges, and institutes. Both columns and rows of the matrix in Table 7.7 list FTE faculty in the Department of Geology and Geophysics (neither adjunct nor joint faculty with adlocs in other departments are shown). Peer-reviewed papers and collaborative research projects over the period 2005-2009 appear as shaded entries, and numbers indicate funded research grants and contracts. Numbers along the matrix diagonal indicate the total number of funded projects of individual faculty members, whether they are sole-PI or have co-PIs. Off-diagonal entries represent collaborations between department faculty members. Collaborations with other TAMU researchers and colleagues at other institutions are shown at the bottom.

The number of off-diagonal entries for co-authored papers and unfunded research projects indicate a healthy level of collaboration within the department; yet funded collaborative projects tend to support research collaborations external to the department. Significant numbers of Geology and Geophysics faculty participate in funded research with faculty members of Oceanography and Geography Departments, and members of IODP, Petroleum Engineering, and other departments of Texas A&M University. Virtually all faculty have active research collaborations with researchers at out-of-state universities, and many collaborate with international colleagues in Europe, Japan, and/or China.
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| Ocean/Geog     | 2   |         |            |            |      |     |         |          |        |          |        |         |        |            |      |             |           |          |          |        |          |      |      |       |     |       |
| IODP           | 1   |         |            |            |      |     |         |          |        |          |        |         |        |            |      |             |           |          |          |        |          |      |      |       |     |       |
| PETE           | 1   |         |            |            |      |     |         |          |        |          |        |         |        |            |      |             |           |          |          |        |          |      |      |       |     |       |
| Engin Depts    | 3   | 2       |            |            |      |     |         |          |        |          |        |         |        |            |      |             |           |          |          |        |          |      |      |       |     |       |
| TAMU Other     | 2   | 2       | 2           |            |      |     |         |          |        |          |        |         |        |            |      |             |           |          |          |        |          |      |      |       |     |       |

| EXTERNAL - TAMU|      |         |            |            |      |     |         |          |        |          |        |         |        |            |      |             |           |          |          |        |          |      |      |       |     |       |
| US Institutions| 1   | 3       | 17          |            |      |     |         |          |        |          |        |         |        |            |      |             |           |          |          |        |          |      |      |       |     |       |
| International  | 1   | 1       | 2           |            |      |     |         |          |        |          |        |         |        |            |      |             |           |          |          |        |          |      |      |       |     |       |

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7.6 Faculty Recognition and Service

Faculty of the Department of Geology and Geophysics have been recognized for their research and educational contributions. Leadership and stature of the faculty in the broader scientific community are indicated by invitations to give keynote lectures, and positions of responsibility held. Awards presented to faculty over 2005-2009 are listed in Appendix F, keynote and invited lectures are listed in Appendix G, and professional activities, including editorships, participation on funding panels, memberships on national and international committees, and participation at workshops and meetings, are listed in Appendix H.

Four named chairs, seven endowed professorships, and two university Regents Professorships have been awarded or held in the department (Table 3.22, Appendix F) over the last five years. Geology and geophysics faculty have received one college-level research award and five college/university-level teaching awards over the same period. Members of the Department received ten awards from professional societies over 2005-2009, five for research excellence, four for teaching excellence, and one recognizing mentoring. Notably, high honors have been awarded both junior and emeritus faculty: Dr. Olszewski received the 2009 Schuchert Award (Paleontological Society), Dr. Wade received the 2009 Hodson Award (Palaeontological Association), Dr. Bouma received the 2007 Sidney Powers Award (AAPG) and was named Geo-Legend in 2006 by the Houston Geological Society, and Dr. Rabinowitz received the 2009 Industry Pioneer Award (Offshore Energy Center). Dr. Wade received a NSF Career Award this year, and four faculty received fellowship in professional societies over the last five years, three to the Geological Society of America (Drs. Grossman, Pope, Zhan), and one to the Society of American Military Engineers (Dr. Mathewson).

Geology and geophysics faculty have given over 150 invited talks over the period 2005-2009, some as keynote speakers of Chapman Conferences (listed in Appendix G) and Gordon Research Conferences (Drs. J. Chester, J. McGuire are listed only by name as 2008 Gordon Conference speakers, Appendix G, without titles or citation according to GRC policy). Seventeen department members have served as editors or associate editors of scientific journals over this time period and five are on editorial boards. These journals include:

- AAPG Bull.
- Geobiology
- Geology
- Geol. J.
- Geomorphology
- Geophysics
- Geophys. J. Int.
- Int. J. Coal Geol.
- J. Comput. Acoustics
- J. Contam. Hydrology
- J. Hydrology
- J. Seismic Explor.
- J. Struct. Geol.
- Lithos
- Paleobiology
- Palaios
- Water Resources Res.
- Open Paleo J.
Faculty served on over 35 national and international committees, and chaired or organized a similar number of special sessions at national meetings and conferences. A number of faculty members have served on review panels of funding agencies, including:

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Faculty of the department participated in over 50 NSF-sponsored or DOE-sponsored research and education workshops.
Chapter 8 - Summary

The last strategic plan of the Department of Geology and Geophysics was prepared in 2005, following our 2002 External Review (Appendices I and H, respectively). Since 2005, we have continued to refine the department's priorities with the assistance of workshops hosted by the Geology and Geophysics Advisory Council (GEODAC). We look forward to the results of the present External Review and expect to develop a new strategic plan over the spring semester, 2010 in light of the review's findings and insight.

8.1 Status of Strategic Plan

As a large geoscience department at one of the two largest state universities of Texas, and with affiliations in the College of Geosciences and university, we believe that we have opportunities to build our reputation in four areas:

1. Petroleum Geosciences
2. Water Resources and Environmental Geosciences
3. Tectonophysics, Deep Crust and Mantle Dynamics
4. Life, Climate and Earth History

In prior chapters, we have attempted to establish these as our traditional and emerging strengths. We believe that we can develop these programs further to meet the university's challenges of Vision 2020 with current faculty, with new faculty hired to complement current strengths, and with allocation of resources that will allow our educational and research programs to flourish.

Core Values

While open debate and scrutiny are daily staples of our academic culture, we have been convinced by the department's advisory council (GEODAC) that our academic and professional goals can be reached if we develop a common understanding of core values and live by them. Our core values include:

1. The clear articulation of our vision and goals.
2. Our priorities and expectations reflect our goals.
3. As individuals and as a community, we take responsibility for accomplishing our goals.
4. Openness, honesty and listening lead to mutual trust and effective communication.
5. We value all members of our community for their contributions, and we respect their opinions and diverse perspectives regardless of position or background.
6. We have a life-long commitment to learning and teaching.
7. Sustained productivity and creativity require balance and perspective.
8. A culture of intellectual curiosity, scientific rigor, and collaboration will inspire excellence.
9. Striving for improvement will lead to success.

**Accomplishments and Shortfalls**

In our 2005 Strategic Plan, we established academic goals for our graduate and undergraduate programs, faculty research productivity and extramural funding, and building our faculty and technical staff hiring.

We have improved our undergraduate program by 1) establishing new, writing-intensive courses, 2) providing students with in-house tutoring in math and physics to improve their backgrounds and performance in math and background science courses, 3) involving more undergraduate students in research, 4) maintaining our summer field course (Geol 300) as the capstone course of the Geology B.S. program, and providing additional field exercises in other geology and geophysics courses. Our undergraduate program assessments are encouraging (Appendix B), and we are pleased by the number of our majors who go on to graduate geology and geophysics programs, or take geoscience jobs. We are pleased by the number of undergraduate students who are offered summer internships and by the number of undergraduates who are introduced to research, either through individual projects with faculty or as participants in funded research projects.

We have attempted to improve our graduate program by 1) elevating our admissions standards, 2) improving our graduate student stipends, at the same time that the University has released graduate students from tuition and benefits costs, 3) establishing and communicating clear expectations to our graduate students and reinforcing these with fellowship and scholarship guidelines that emphasize scholarship and research accomplishment. Our students benefit from active on-campus recruiting and from summer internships. Placement of our students in applied geoscience careers is excellent (Appendix C). We are also proud of those students who have brought their M.S. theses and Ph.D. dissertations into print in peer-reviewed journals (Appendix C) and have initiated their own academic careers as faculty at universities and colleges. However, our graduate program assessment indicates that we are not meeting our goals in student-authored publications. Many M.S. Thesis research projects are never published and a number of our Ph.D. students publish fewer peer-reviewed papers than will make them competitive for faculty or government lab research openings.
We are proud of the active, young faculty we have hired in recent years. Their ambitions, scholarly backgrounds, and ability to address important scientific questions have largely been responsible for recent increases in research funding of the department. We have also attempted to improve the research environment of the department by hiring postdoctoral researchers, who are able to invest their full time to research, collaborate with faculty and students, and provide outstanding mentoring to our Ph.D. (and M.S.) students. All five postdoctoral fellows of the department are outstanding young scientists. Dr. J. Moore has co-authored a 2008 paper in *Science*, Dr. Holyoke has been invited to give a keynote lecture at a Gordon Research Conference this coming summer, 2010, and all five have contributed to the development of new research proposals.

After extended efforts (and some setbacks) to rebuild our traditional strength in petroleum geosciences, collaborations with faculty of TAMU’s Petroleum Engineering Department, and ties with the energy industry, we are on the threshold of rebuilding our strength in petroleum geosciences. We have successfully hired outstanding sedimentary geologists, we have established the Berg-Hughes Center for Petroleum and Sedimentary Systems, and we have attracted an experienced leader to direct this center. With Dr. Hopper’s loss from the Department, we are working to rehire a reflection seismologist who will rebuild our geophysics program and collaborate with geologists, geophysicists, and petroleum engineers of the Berg-Hughes Center.

The Department has new research strengths in radiogenic and isotope geochemistry, supplementing our environmental geochemistry capabilities. The Department has invested in outstanding new geochemistry faculty and the College of Geosciences has invested in state-of-the-art analytical facilities. Our geochemistry faculty have developed ties with Oceanography and Geography, and with the Integrated Ocean Drilling Program (IODP) and they have strengthened our developing Deep Crust and Mantle Dynamics focus. The department and college have succeeded in hiring outstanding ODASES faculty to build on research collaborations with scientists of the IODP. However, we have failed to build the environmental geosciences with a critical faculty hire in hydrogeology and we have lost a biogeochemist. Our environmental geosciences program needs an applied hydrogeologist who can collaborate with our current faculty, with strengths in hydrogeology theory and modeling and environmental geochemistry and biogeochemistry, and with faculty across campus in the university’s Water Management and Hydrological Sciences Program. We recently lost an important faculty member, Dr. J. McGuire, whose biogeochemical research was well funded and attracted excellent students to our graduate program. We need to build our environmental geosciences in this area as well, supplementing the research of Drs. Herbert and Tice.

Tectonophysics was identified as a strength of the Department in our 2002 review, but without significant investments in faculty replacements and facilities, it will be difficult to re-establish this
strength of the department. We attempted but failed to hire faculty with specialties in rock mechanics, geodynamics, and tectonic geodesy, who would have strengthened this research area. As the John Handin Laboratory ages, it will also be important to rebuild this laboratory if we wish to continue to lead in this area. Funding in tectonophysics has continued to be strong, and we have the opportunity to rebuild a unique strength that will be competitive, nationally and internationally.

Through Reinvestment and ODASES faculty hires and the development of state-of-the-art stable and radiogenic isotope geochemical laboratories, we have invested in developing a strong program in Life, Climate, and Earth History. This group is particularly well positioned to make research and educational contributions with opportunities to collaborate with colleagues throughout the College of Geosciences and the IODP.

The Department has managed to maintain a small staff of technicians and a research professor to facilitate research by operating and maintaining the John Handin tectonophysics lab, the electron microprobe lab, and geochemistry laboratories. All of these individuals contribute to educational objectives, in support of teaching laboratories, as well as facilitating our research. However, we are still challenged to maintain our facilities, and we could use more technical support.

8.2 New Initiatives and Planning

Looking ahead, we seek input into our perceived needs to:

- Build and reinforce our geoscience community of students, staff, and faculty.
- Revisit and modernize our undergraduate curricula.
- Maintain our undergraduate program standards, as student numbers increase.
- Improve our graduate program through student recruiting, to increase our population of research-oriented Ph.D. students.
- Foster a culture of student publication.
- Increase the level of research funding.
- Enable competitive offers to new faculty.
- Provide needed laboratories and infrastructure to faculty and students.
- Rebuild the Graduate Petroleum Geosciences Program.
- Build the Graduate Environmental Geosciences Program.
- Build the Tectonophysics, and Deep Crust and Mantle Dynamics Programs.
- Maintain and strengthen the Life, Climate, and Earth History Program.
The most important factor in recruiting and retaining faculty and students is the community of colleagues and scholars that makes the department its academic home. Excellent colleagues engaged in collaborations that are exciting and productive are also essential to our successes in teaching and research. We have made attempts to build a geoscience community of students, staff, and faculty who excel through collaborative pursuit in teaching and research. Our "community of geoscientists" includes members of our department, its adjunct and joint appointments, and members of the College of Geosciences, its departments and centers. By "students" we include undergraduate, graduate, and former students. We include staff and faculty of all ranks as we depend on all department members to administer and run our programs. "Collaboration" is a key in our strategy, to deliver higher quality education, to innovate, and to draw on different disciplines in our research. Collaborations within the department are valued, but collaborations with colleagues throughout Texas A&M University and at other institutions are also important.

Undergraduate Programs

Our assessment of the Department's undergraduate programs indicates that we are meeting our program missions. Nevertheless, we plan to re-examine a number of courses to bring a modern perspective to their presentation and incorporate more problem solving in courses that have traditionally been more qualitative. We are extremely pleased that generous contributions enable us to cover expenses of our summer field course (Geol 300); over the next three years, we will be able to cover student field course fees, and offer field scholarships to compensate students for their diminished summer job savings. Ultimately, we would like to establish an endowment to cover student field costs. We hope to build on recent successes in offering undergraduate research opportunities, by establishing one-on-one partnerships between graduate students engaged in their thesis or dissertation research and undergraduate students who will benefit from research experiences as they assist in the research endeavor. We are encouraged by the recent growth in our undergraduate student population. However, this also poses new challenges as we attempt to maintain our standards, and offer small courses with hands-on laboratory, field, problem-solving, and/or writing-intensive exercises. Given that the College of Geosciences does not have the budget to hire faculty at the rate that our student numbers are growing, our ability to offer small, high quality courses is threatened, as are the fundamental goals of the university's Faculty Reinvestment Program.

Graduate Programs

Assessments of our graduate programs are mixed by comparison with our assessments of undergraduate programs. Our graduate students readily find employment in the energy industry, and they benefit from summer internships with oil and gas companies. In recent years, we have also placed some of our Ph.D. students in faculty positions. However, our attempts to raise admissions standards have decreased our total student numbers, particularly over the time period
when the department lost critical faculty in applied petroleum geosciences and our website suffered from IT staff changes. Faculty and student members of the department have increased their efforts to recruit new students, with record numbers of students contacted at national meetings of the Geological Society of America. In addition, we have made invitations to our annual recruiting weekend. However, competition from other graduate programs has also increased, and we have lost top-ranked candidates to graduate programs that made 1) early offers, 2) offers with larger graduate stipends, and 3) offers of guaranteed, multi-year fellowships.

Increasing the number of Ph.D. students in our program remains one of our greatest challenges. We need to develop the ability to make better offers to the very best applicants, and work with students on their writing skills. As we attract top students, we need to build a culture of research communication and publication. We have introduced writing-intensive courses for our graduate students with the goal of working on student writing skills at an early stage in the program, well before students begin to write their theses, dissertations, and papers.

**Research Funding and Support**

We recognize the need to increase our research funding. Gaining research funding should be facilitated by greater contributions of Ph.D. students to our research productivity. Our research funding has increased in recent years, owing largely to the efforts of the excellent young faculty who have joined the Department. However, we may also need to reevaluate our balance of faculty time dedicated to teaching and research. The Department of Geology and Geophysics at Texas A&M University makes a bigger investment in science education for non-majors than perhaps any other geoscience department in the nation. While we remain committed to the university's core courses, young faculty need to dedicate significant time to initiate their research and obtain funding. Greater support of graduate students through research grants would facilitate student dedication and effort to bring their research to publication.

As we initiate searches for new faculty positions, it will be important to identify funds for faculty start-up packages. New faculty start-up funds come 1) from indirect research charges that go to the University, College of Geosciences, and departments according to PI affiliation, and 2) from faculty salary savings that accrue in College accounts when faculty retire (or leave TAMU early) and are not replaced immediately. With the number of recent hires and losses in the Department of Geology and Geophysics, we have dedicated significant funds to new faculty start-up, and we will be hard pressed to come up with competitive start-up offers for new faculty (unless the instrumentation/laboratory needs of new faculty candidates are identical to those of faculty who left). Start-up funds are critical to make competitive offers to the best faculty candidates, and they are essential to initiate the research of new faculty and their students. This problem could be solved if faculty salary savings were not centralized, but were split evenly between the College of
Geosciences and the department where faculty members have been lost and/or where new faculty are needed.

**Building on Strengths**

The Department and College of Geosciences have recently invested significant resources to rebuild our strength in petroleum geosciences. We have hired outstanding faculty, Drs. Mancini, Pope, Sun, Tice, and Weiss, who contribute to sedimentary geology, and petroleum geology and geophysics. Adding to the expertise of Drs. Ahr, Gibson, Ikelle, Wiltschko, and others with research interests in petroleum geosciences, we have extended our capabilities beyond those when we experienced our faculty losses. We have initiated a new Petroleum Geoscience Certificate, and obtained approval from the Board of Regents to establish the Berg-Hughes Center for Petroleum and Sedimentary Systems, secured with new endowments exceeding $2.9M. One of the principal goals of the Berg-Hughes Center is to facilitate interdisciplinary research between members of our department, faculty and students of Oceanography and Petroleum Engineering, and colleagues in the energy industry.

The Department has also made investments and plans to build our program in environmental geosciences. We have attempted and failed to hire a hydrogeologist to complement our current strengths in hydrogeology theory and modeling, and environmental geochemistry. New faculty in this area would contribute to the university's Water Management and Hydrological Sciences Program and to the College of Geoscience's undergraduate Environmental Geosciences Program. We also seek to replace our loss of Dr. J. McGuire with a biogeochemist. Funding opportunities for both these prospective new faculty can be identified from NSF, EPA, and DOE. If graduate education and research in water resources and environmental geosciences are to thrive in our department, we will need to succeed in attracting active young scientists and make start-up offers that build on the laboratories that our current faculty have established. With new research needs to conduct hydrogeological field experiments and analytical measurements, we anticipate the need to hire a new technician in environmental geosciences.

The Department attempted but failed to rebuild our strength in tectonophysics, as was recommended in our 2002 External Review. Faculty offers were made to outstanding scientists in experimental rock mechanics, geodynamic modeling, and geodesists who use GPS, InSAR, and LIDAR to monitor displacements in tectonically active regions; however, competitive offers made by other institutions prevailed. We plan to reinitiate our search for faculty who can strengthen our research in tectonophysics, deep crust and mantle dynamics, seeking candidates who can benefit from our experimental facilities and from such funding initiatives as NSF Earthscope and Margins, and NSF Programs in Continental Dynamics, Tectonics, and Geophysics. The John Handin Rock Deformation Laboratory could become an internationally recognized
laboratory again. However, real investments would be required, comparable to those made in state-of-the-art radiogenic and stable isotope geochemistry laboratories.

With ODASES faculty hires in our department and the College of Geosciences, we have established a department strength in life, climate, and Earth history research and education. We wish to maintain and strengthen this area of graduate research and contribute to College of Geosciences interdisciplinary climate initiatives. There are multiple opportunities to collaborate in geobiology, paleobiology, paleoclimatology, and paleoceanography, with faculty and students of our department, and members of Departments of Oceanography, Atmospheric Sciences, and Geography, and research scientists of IODP.

The Department of Geology and Geophysics has a proven record of hiring outstanding young faculty. We also have good records of providing excellent programs for undergraduate and M.S. students with practical professional career goals. We have yet to demonstrate that we can retain outstanding faculty and attract a larger population of outstanding research-oriented Ph.D. students. We recognize that performing well in applied and fundamental geosciences is a challenge. It would be easier to gain recognition in just the applied energy and environmental geosciences or the academic world of fundamental geosciences. However, we are committed to this challenge. We have confidence that unforeseen applications come from curiosity and fundamental understanding in the sciences. We have confirmation of John Handin's observation at Shell laboratories, that "sometimes unforeseen curiosity and fundamental science come from the need to solve practical problems."
Front Cover  experimentally compacted St Peter sand with Hertzian cracks generated at grain contacts (SEM image by J. Chester, from Masters thesis research of S. Lenz, 2002)

Back Cover  stress heterogeneity (color) and contact force chains (black lines) in numerical model of uncemented packed grains under load (modeling of D. Sparks)
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Appendix A. Curricula Vitae

A.1. Current FTE Faculty
CURRICULUM VITAE
Wayne M. Ahr, Joint Professor, Geology and Geophysics, and Petroleum Engineering

B.S. (Geology), University of Texas El Paso 1960
M.S. (Oceanography), Texas A&M University 1965
PhD (Geology), Rice University 1967

Professional Experience
2002-present Joint Appointment as Professor of Petroleum Engineering and Professor of Geology & Geophysics, Texas A&M
1995-2002 Mollie B. and Richard A. Williford Professor of Petroleum Geology and Geophysics, Texas A&M
1983-1995 Professor of Geology, Texas A&M
1976-1983 Associate Professor of Geology, Texas A&M
1970-1976 Assistant Professor of Geology, Texas A&M
1967-1970 Exploration Geologist, Shell Oil Co., Houston

Honors and Awards
2010 American Association of Petroleum Geologists Grover E. Murray Memorial Distinguished Educator Award (April meeting, 2010)
2008 Gulf Coast Association of Geological Societies Outstanding Educator Award
2005 Association of Former Students (Texas A&M) Distinguished Achievement Award for Teaching (College Level)
2003 Best Paper Award (with student J. Layman), W. Texas Geol. Society
2002 Best Paper Award – 2nd Place (with student T. Hopkins), AAPG National Meeting

Courses Taught (Five Years)
Geol 400 Integrated Reservoir Description [Cross Listed with Petroleum Engineering] Geol 619 Petroleum Geology
Geol 404 Petroleum Geology Geol 624 Geology of Carbonate Reservoirs
Geol 623 Carbonate Rocks Geol 689 Integrated Reservoir Analysis

Students Advised – Four Years

<table>
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<tbody>
<tr>
<td>Adams, Aaron</td>
<td>Lafage, Stephanie</td>
<td>Kelli Spaugh</td>
</tr>
<tr>
<td>Poole, Katherine</td>
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<tr>
<td>Fisher, Aaron</td>
<td>Mason, Eric</td>
<td>Humbolt, Aubrey</td>
</tr>
<tr>
<td>Lodola, Domenico</td>
<td>Genty, Coralie</td>
<td>Vera, Riene</td>
</tr>
<tr>
<td>Mazingue, Vincent</td>
<td>Dicus, Christina</td>
<td></td>
</tr>
</tbody>
</table>

Five Recent Publications


Five Influential Publications


Ahr, W.M., and B.S. Hammel (1999) Identification and mapping of low units in carbonate reservoirs: an example from the Happy Spraberry (Permian) field, Garza County, Texas, USA, Energy Exploration and Exploitation, 17, 311-334. 4 Citations (Nov 2009)


Research Publications 60 Refereed articles, books, chapters in books, and book reviews. 83 abstracts from presentations at international, national, and regional professional meetings/conferences, 124 citations

Selected Projects with Outside Funding (Five Years)


Anderson Energy Partners, Identification and quality ranking of reservoir flow units, Jurassic Smackover Formation at Grayson field, Arkansas employing comparative study of image analysis, measured poroperm values, and NMR measurements— September 1 2005 – August 31 2006, . $22,785 PI W. Ahr.

Service and Professional Activities (Five Years)

2008 – Present Departmental Executive Committee
2008 – Present Graduate Committee
2008 - 2009 Soft Rock Search Committee
2004 – Present Associate Editor, AAPG Bulletin
CURRICULUM VITAE
Richard L. Carlson, Regents Professor

Ph.D., M.S., B.S. (Geological Sciences), University of Washington, 1977, 1972, 1970

Professional Experience
2008-present Program Director, National Science Foundation
2003-present Regents Professor, Department of Geology and Geophysics, Texas A&M University
2002-2009 Dudley J. Hughes Chair, Department of Geology and Geophysics, Texas A&M University
2003-2006 Head, Department of Geology and Geophysics, Texas A&M University
1993-present Professor, Dept. of Geology and Geophysics, Texas A&M University
1986-2003 Professor of Geophysics, Texas A&M University
1987-1996 Associate Director, Geodynamics Research Institute
1983-1986 Associate Professor of Geophysics, Texas A&M University
1977-1983 Assistant Professor of Geophysics, Texas A&M University

Honors and Awards
2003 Regents Professor, Texas A&M University
2002 Dudley J. Hughes Chair, Dept. Of Geology & Geophysics
1996 TAMU Geosciences Distinguished Research Award

Courses Taught (Five Years)
Geol 104 Principles of Geology
Geol 435 Geophysics Methods
Geol 611 Geomechanics

Students and Postdocs Advised (Five Years)
2003-2004 Omyung Kwon Post-doctoral Fellow
2002-2005 Ezequiel Genova MS Student Chevron

Five Recent Publications


**Five Influential Publications**


**Research Publications** 60 refereed journal articles, 12 articles and conference proceedings publications, editor 3 proceedings volumes, 58 presentations at national and international conferences. 746 total citations

**Selected Projects with Extramural Funding (Five Years)**


**Service and Professional Activities (Selected, Five Years)**

2008-present Program Director, National Science Foundation
2008-2009 Texas A&M University Vice President for Research President Search Advisory Committee, Member
2002-2008 Texas A&M University Athletic Council, Member
2003-2006 Head, Department of Geology & Geophysics
2003-2006 College of Geosciences Executive Committee, Member
2006-2008 Texas A&M Faculty Senate, Member
2005-2008 Texas A&M Faculty Senate Executive Committee, Member
CURRICULUM VITAE
Frederick M. Chester, Professor and Harris Chair

Ph.D. (Geophysics), Texas A&M University, 1988.
M.S. (Geology), Texas A&M University, 1983.
B.A. Geology (Geophysics option), University of California at Santa Barbara, 1980.

Professional Experience
2002–present  Professor of Geology & Geophysics, Texas A&M University.
1997–2002  Associate Professor of Geology & Geophysics, Texas A&M University.
1994–1996  Associate Professor of Geophysics, Saint Louis University.
1990–1994  Assistant Professor of Geophysics, Saint Louis University.
2/89–1/90  Associate Research Scientist, Lamont-Doherty Geol. Observatory, Columbia Univ.
1/88–2/89  Postdoctoral Fellow, Lamont-Doherty Geol. Observatory, Columbia University.

Honors and Awards
2009  David B. Harris Chair in Geology
2009  American Rock Mechanics Association Research Award
2001  Texas A&M University Faculty Fellow.
1993  Saint Louis Univ. Graduate School Research Committee Grantsmanship Award.
1985–1987  John and Frances Handin Graduate Fellowship, Texas A&M University.
1980  Outstanding Graduating Senior, Geological Sciences, Univ. Calif. at Santa Barbara.

Courses Taught (Five Years)
- Geol 101 Principles of Geology
- Geol 101H Principles of Geology, Honors
- Geol 311W Principles of Geol. Writing
- Geop 660 Physics of the Earth’s Interior
- Geol 663 Fracture and Faulting of Rock

Students and Postdocs Advised (Five Years)

Active
- Robert Choens  Ph.D. Geology (2012)
- Clayton Coble  M.S. Geology (2010)
- Gokturk Dilci  M.S. Geology (2010)

Graduated
- Robert Choens  M.S. Geology, 2009  TAMU
- Anne Herrin  M.S. Geology, 2008  Hess Corp.
- Taka Kanaya  M.S. Geology, 2006  Hess Corp.
- Jennifer Bobich  M.S. Geology, 2005  Shell
- Stephen Karner  Post-doc, 2002-2004  ExxonMobil
- Jorge Nieto  M.S. Petrol. Eng., 2004  Pemex

Five Recent Publications


**Five Influential Publications**


**Research Publications** 30 refereed journal articles, chapters and conference proceedings publications, 100 presentations at national and international conferences. 1400 total citations (Sept 2009).

**Selected Projects with Extramural Funding (Five Years)**


NSF- EAR-0454525, Collaborative Research: Structural-Petrologic Characterization of the San Andreas Fault Zone in the SAFOD Drill Holes, 6/05-5/08, $244,975, $119,982 (TAMU budget), Co-PI J.S. Chester. Collaborative research with J. P. Evans, D. Kirschner.

NSF- EAR-0310284, Experimental and Petrofabric Study of Hybrid Fractures and the Transition from Joints to Faults, 6/03-5/06, $299,546, Co-PI J.S. Chester.

**Additional Grants** (Last Five Years): 3 additional funded projects and 1 funded workshop.

**Service and Professional Activities (Selected, Five Years)**

2009 Panelist, proposal review for USGS National Earthquake Hazard Reduction Program.


2007-2008 Shipboard Scientist, IODP NanTroSEIZE (Stage 1) Expedition #316.

2005-2006 Panelist, proposal review for NSF Geophysics program.


2004-present Member, San Andreas Fault Observatory at Depth (SAFOD) Science Team, 2004-present.

2009-present Member, College of Geosciences Faculty Advisory Committee, Texas A&M University.

2008-present Chair, Space Utilization Committee, Dept. Geology & Geophysics, Texas A&M University.

2007-present Director, Center for Tectonophysics, Texas A&M University.
CURRICULUM VITAE
Judith S. Chester, Associate Professor
Ph.D., M.S. (Geology), Texas A&M University, 1992, 1985
B.S. (Geology), UCLA, 1979

Professional Experience
2004-present  Associate Professor of Geology, Texas A&M University
2001-2004  Assistant Professor of Geology, Texas A&M University
2001  Senior Lecturer, Texas A&M University
1997-2001  Lecturer, Texas A&M University
1992-1996  Assistant Professor of Geology, Dept. of Earth & Atmos. Sci., Saint Louis Univ.
1989-1991  Adjunct Instructor, College of Arts & Sciences, Saint Louis University

Honors and Awards
2009  American Rock Mechanics Association Research Award
2003  El Paso Energy Foundation Faculty Achievement Award
2002-2003  Montague-Center for Teaching Excellence Scholar

Courses Taught (Five Years)
Geol 101  Principles of Geology
Geol 665  Structural Petrology
Geol 101H  Principles of Geology, Honors
Geol 685  Directed Studies in Scientific Writing
Geop 681  Tectonophysics Seminar

Students and Postdocs Advised (Five Years)
2008-present  Bretani Heron  MS Student  ExxonMobil
2008-present  Clayton Coble  MS Student  ExxonMobil
2007-present  David Sills  MS Student  ExxonMobil
2005-present  Hiroko Kitajima  PhD Student  ExxonMobil
2008-present  James Orofino  MS Student  HS Teacher

Five Recent Publications
Five Influential Publications


Research Publications 21 refereed journal articles, articles and conference proceedings publications, 79 presentations at national and international conferences. 461 total citations.

Selected Projects with Extramural Funding (Five Years)


NSF-EAR-0510892 (SCEC subcontract), Characterization of Pulverized Granitoids in the Little Rock Core Along the San Andreas Fault, 02/09-1/12, Co-PIs T. Rockwell and Y. Ben-Zion, $40,000 total, $7,000 (TAMU).

NSF-EAR-0510892 (SCEC subcontract), Frictional Strength and Microstructures of SAFOD Gouge Sheared at Coseismic and Aseismic Creep Rates, 02/08-1/12, Co-PI F.M. Chester, Collaborators J.P. Evans, D. Kirschner.

E-2008-ETC-009, X-Ray Computed Tomography (CT) Study of Phase 3 Spot Core from the San Andreas Fault Observatory at Depth (SAFOD), 01/08-12/08, ExxonMobil, $25,000.

NSF- EAR-0454525, Collaborative Research: Structural-Petrologic Characterization of the San Andreas Fault Zone in the SAFOD Drill Holes, 6/05-5/08, $244,975, $119,982 (TAMU budget), Co-PI F.M. Chester. Collaborative research with J. P. Evans, D. Kirschner.

NSF- EAR-0310284, Experimental and Petrofabric Study of Hybrid Fractures and the Transition from Joints to Faults, 6/03-5/06, $299,546, Co-PI F.M. Chester.

Additional Grants (Last Five Years): 5 additional funded projects and 4 funded workshops.

Service and Professional Activities (Selected, Five Years)

2006-present Leader, Fault and Rupture Mechanics Group, So. California Earthquake Center (SCEC)

2008-2009 NSF EarthScope Distinguished Speaker


2008 Session Chair, Fault Zone Structure & Mechanics Workshop, SCEC, CA, June 11-12.


2004 Program Committee Member, AGU Chapman Conference, Radiated Energy and the Physics of Earthquake Faulting, Portland, Maine, June 13-17.

CURRICULUM VITAE

Bradford Mark Clement, Professor and Director of Science Services, Integrated Ocean Drilling Program

Ph.D. (Geology), Columbia University, 1985
M.A. (Geology), Columbia University, 1981
B.S. (Geology), University of Georgia, 1979

Professional Experience

1984-1988 Staff Scientist, Ocean Drilling Program & Adjunct Assistant Professor, Department of Geophysics, Texas A&M University
2001-2003 Associate Program Director, Ocean Drilling Program, Ocean Sciences Division National Science Foundation, Arlington, VA
1988-2009 Professor and Chair, Department of Earth & Environment, Florida International University Miami, Florida, 33199

Honors and Awards

Phi Beta Kappa, Phi Kappa Phi
Graduated Magna Cum Laude with honors in Geology
Faculty Fellow of Columbia University
1994 FIU Teaching Incentive Program Award for excellence in undergraduate teaching,
2000 FIU Outstanding Teaching Award,
2005 FIU Excellence in Research Award,

Courses Taught

Undergraduate Courses
Physical Geology
Environmental Geology
Physical Oceanography
Introduction to Exploration Geophysics
Marine Geology

Graduate Courses
Paleomagnetism
Physics of the Earth

Five Recent Publications


**Service and Professional Activities (University)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity</th>
</tr>
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<tbody>
<tr>
<td>1991-1995</td>
<td>FIU College of Arts &amp; Sciences Curriculum Committee</td>
</tr>
<tr>
<td>2004</td>
<td>FIU School of the Environment Taskforce</td>
</tr>
<tr>
<td>2005</td>
<td>FIU Taskforce on forming a School of Science within the College of Arts and Sciences, Chair</td>
</tr>
<tr>
<td>2005</td>
<td>FIU Search committee for Associate VP of Research</td>
</tr>
<tr>
<td>2006-2007</td>
<td>FIU Search committee for Dean, College of Arts and Sciences</td>
</tr>
<tr>
<td>2006-2007</td>
<td>FIU Taskforce on Evaluating A&amp;S department chairs</td>
</tr>
<tr>
<td>2004-present</td>
<td>FIU Science Chairs (informal working group), chair</td>
</tr>
<tr>
<td>2007-present</td>
<td>FIU Joint Administrative-Faculty Senate Strategic Planning Committee</td>
</tr>
<tr>
<td>2007-present</td>
<td>College of Arts &amp; Sciences Strategic Planning Steering Committee</td>
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**Professional Affiliations & Service**

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity</th>
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<tbody>
<tr>
<td>1990 - 1992</td>
<td>Associate Editor for the Journal of Geophysical Research</td>
</tr>
<tr>
<td>1989 - 1991</td>
<td>Member of the AGU committee on Paleoceanography</td>
</tr>
<tr>
<td>1992 – 1994</td>
<td>Member of the JOI/U.S. Science Advisory Committee</td>
</tr>
<tr>
<td>1994 – 1997</td>
<td>Member of the JOIDES Ocean History Panel</td>
</tr>
<tr>
<td>1998</td>
<td>German-American Frontiers of Science Meeting (NAS), Irvine, CA, Organizing Committee, member</td>
</tr>
<tr>
<td>1999</td>
<td>German-American Frontiers of Science Meeting (NAS), Potsdam, Germany, Organizing Committee, Chair</td>
</tr>
<tr>
<td>2003-2005</td>
<td>Member of the AGU Index Committee</td>
</tr>
<tr>
<td>2003</td>
<td>Member of the AGU GP Section Exec. Committee</td>
</tr>
<tr>
<td>2006-2009</td>
<td>Member of the COL/U.S. Advisory Committee</td>
</tr>
</tbody>
</table>
CURRICULUM VITAE
Benchun Duan, Assistant Professor

Ph.D. (Geology), University of California, Riverside, 2006
M.S., B.S. (Geophysics), Ocean University of China, 1994, 1991

Professional Experience
2007-present  Assistant Professor of Geology & Geophysics, Texas A&M University
2006-2007  Postdoctoral Researcher, San Diego State University
1994-2001  Lecturer and Researcher, Ocean University of China (OUC)

Honors and Awards
1998  OUC Science and Technology Achievement Award

Courses Taught (Five Years)
Geol 101  Principles of Geology
Geop 611  Geomechanics
Geop 660  Physics of the Earth's Interior
Geop 689  Earthquake Physics

Students and Postdocs Advised (Five Years)
2009-present  Jingqian Kang  PhD Student  Texas A&M
2009-present  Zaifeng Liu  PhD Student  Texas A&M
2009-present  Jinquan Zhong  Post-doctoral Fellow  Texas A&M

Five Recent Publications


Three Influential Publications


**Selected Projects with Extramural Funding (Five Years)**


**Service and Professional Activities**

- **2005-present**  
  Key participant of SCEC dynamic code validation project
- **2007-present**  
  Reviewer for Nature, JGR, GRL, BSSA, and GJI
- **2008-present**  
  Reviewer for NSF
- **2007-present**  
  Member, Graduate, Undergraduate, and IT committees, Department of Geology and Geophysics
CURRICULUM VITAE
Dr. Mark E. Everett, Professor, Texas PG #5141

Ph.D. (Geophysics), University of Toronto, 1991
M.Sc., B.Sc. (Physics), York University (Canada), 1987, 1985

Professional Experience
2003-present  Professor of Geology and Geophysics, Texas A&M University
1997-2003  Associate Professor of Geophysics, Texas A&M University
1995-1997  Assistant Professor of Geophysics, Texas A&M University
1993-1994  Post-doctoral Fellow, University of Cambridge, U.K.

Honors and Awards
2009  Howard Karren Professorship in Geology and Geophysics
2008  Dean’s Research Achievement Award, Texas A&M Geosciences
2006  Faculty Fellow, Texas A&M Center for Heritage Conservation
2002  Faculty Fellow, Texas A&M University

Courses Taught (Five Years)
Geol 101  Principles of Geology
Geop 413  Near—surface Applied Geophysics I
Geop 435  Exploration Geophysics
Geop 475  Interpretation of Gravity and Magnetic Fields
Geop 620  Geophysical Inverse Theory
Geop 689  Near—surface Applied Geophysics II

Students and Postdocs Advised (Five Years)
2004-2005  Jakub Velimsky  Post-doctoral Fellow  ETH Zurich, Switswerland
2004-2005  Jiangtao Cheng  Post-doctoral Fellow  Univ. California, Irvine
2007-present  Mark Hickey  PhD Student  Texas A&M
2007-present  Rungrod Arjwech  PhD Student  Texas A&M
2005-present  Souvik Mukerjee  PhD Student  Shell, Houston
2006-2009  Douglas Sassen  PhD Student  Lawrence Berkeley Lab
2005-2008  Suwimon Udphuay  PhD Student  Chiang Mai Univ., Thailand
2007-2008  Changsheng Liu  PhD Student  Jilin Univ., China
2004-2007  Alfonso Benavides  PhD Student  Univ. Caracas, Venezuela
2006-present  Josh Gowan  MS Student  AECOM, New Jersey
2007-2009  Kathryn Decker  MS Student  Boise State Univ.
2006-2008  Roland Fernandes  MS Student  Marathon Oil Co.
2005-2007  David Dickins  MS Student  Marathon Oil Co.
2004-2006  Ryan Lau  MS Student  Marathon Oil Co.

Five Recent Publications


### Five Influential Publications


### Research Publications

48 refereed journal articles, ~100 presentations at national and international conferences. 244 total citations

### Selected Projects with Extramural Funding (Five Years)

- 2009 Texas Department of Transportation $293K *Unknown Foundation Determination for Scour*
- 2007 American Battle Monuments Commission $361K *Pointe du Hoc Stabilization Study (Phase II)*
- 2006 American Battle Monuments Commission $434K *Pointe du Hoc Stabilization Study*
- 2002 U.S. Department of Defense (SERDP) $1.2M *Smart multi—sensor EMI technology for buried target classification*
- 2002 Texas Advanced Technology Program $275K *Improved aquifer characterization using hydraulic tomography*

### Service and Professional Activities (Selected, Five Years)

- 1997-present Editorial Board, *Geophysics*
- 2009 Invited Session Chair, 2nd SWARM Science Meeting (Potsdam, Germany)
- 2008 Peer Review Panelist, AAAS Research Competitiveness Program
- 2008 Member NASA Working Group: Geomagnetism after SWARM
- 2008 Peer Review Panelist, NASA ROSES Earth Interiors program
- 2008 Peer Review Panelist, DOD SERDP program
- 2006 Executive Committee, AGU Near—Surface Focus Group
CURRICULUM VITAE

Paul J. Fox, Joint Professor, Geology and Geophysics, and Oceanography

Ph.D. (Marine Geology/Geophysics), Department of Geology, Columbia University, 1972
B.A. (Geology), Ohio Wesleyan University, 1963

Professional Experience
1995-Present Professor, Departments of Geology and Geophysics, and Oceanography, Texas A&M University
2003-2008 Director of Science Services, U.S. Implementing Organization, Integrated Ocean Drilling Program, Texas A&M University
1995-2003 Director of Science Operations, Ocean Drilling Program, Texas A&M University
1990-1995 Professor of Oceanography, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI
1984-1990 Research Professor of Oceanography, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI
1981-1984 Associate Professor of Research, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI
1977-1981 Associate Professor of Geology, SUNY at Albany, Albany, NY
1972-1977 Assistant Professor of Geology, SUNY at Albany, Albany, NY
1972-1981 Visiting Research Associate, Lamont Doherty Earth Observatory, Columbia University
1964-1971 Research Assistant, Lamont Doherty Earth Observatory of Columbia University

Honors and Awards
1974 Elected Fellow of the Geological Society of America
1983 Conoco Scholar Woods Hole Oceanographic Institution
1989 Visiting Scholar at the Institute of Geological Sciences, Moscow USSR
2000 Elected Fellow of American Geophysical Union
2002 Distinguished University Lecturer Texas A&M University
2002 Texas A&M University Distinguished Achievement Award in Administration
2004 Elected Fellow of the Association for the Advancement of Science

Courses Taught (Five Years)

Geol 101 Principles of Geology (fall 2009)

Five Influential Publications


**Research Publications**


**Projects with Extramural Funding**

Before becoming Director of Science Operations for the Ocean Drilling Program in 1995, I had participated in 36 oceanographic expeditions and had served as Chief or Co-Chief Scientist on 26. These expeditions and the post-cruise work that followed were supported by grants and contracts from NSF and the Office of Naval Research. During my 13 years as Director, I was the lead investigator on a contract to support science operations that ranged from 35 to 50 million dollars/year.

**Service and Professional Activities-An Overview**

SAFOD Advisory Board and on the International Committee to review 10 years of International Continental Drilling

Advisory committees for NSF (NSF Marine G&G Proposal Review Panel, NSF Blue Ribbon Panels), and ONR (Marine Geology and Geophysics Panel)

Steering committees for research initiatives including the International Decade of Oceanography, Deep Sea Drilling Project, Ocean Drilling Program, RIDGE and Inter-RIDGE

Advisory panels including University National Oceanographic Laboratory System, US Science Advisory Committee, Joint Oceanographic Institutions, ALVIN Review Committee, Deep Submergence Science Committee (Chair), and National Academy Ocean Studies Board Committee on Future Research Directions for Oceanography and Major Research Programs

Associate editor for journals *Geology* and *Marine Geophysical Researches*, and editor of Ocean Sciences Section, *EOS Transactions*, American Geophysical Union
CURRICULUM VITAE

J. Rick Giardino, Joint Professor, Geology and Geophysics, and Geography

Ph.D. University of Nebraska, 1979
M.S. Arizona State University, 1971
B.S. Southern Colorado State University, 1969

Professional Experience

1988-present  Professor of Geology and Geophysics and Water Management and Hydrological Science, Texas A&M University
2000  Fellow, The Texas Higher Education Coordinating Board (THECB)
1998-2007  Dean of Graduate Studies, Texas A&M University
1996-1998  Associate Director of the Office of Graduate Studies, Texas A&M University
1989-1996  Department Head, Geography, Texas A&M University
1984-1988  Associate Professor, Geography and Geology, Texas A&M University
1983-1984  Director, Remote Sensing Applications Unit (RSAU) of the International Center for Arid and Semiarid Land Studies (ICASALS), Texas Tech University
1983  Visiting Assistant Professor, University of Colorado
1978-1984  Assistant Professor, Texas Tech University
1977-1978  Instructor, Science Division, Doane College
1973-1974  Acting Head, University of Zambia
1972-1974  Lecturer, University of Zambia

Honors and Awards

1996  TAMU Former Students Association University-Level Disting. Teaching Award
1995  Meritorious Service Award, Geological Society of America
1995  Award for Support & Encouragement, TAMU Hispanic Grad. Student Assoc.
1995  National Council for Geographic Education Distinguished Teaching Award
1989  TAMU Former Students Association College-Level Disting. Teaching Award
1989  Almon Fellow, Hockaday School, Dallas, Texas
1984  Fellow, Geological Society of America
1980  Fellow, Royal Geographical Society, UK

Courses Taught (Five Years)

Geol 101(H)  Principles of Geology (including Honors sections)
Geol 689  Special Topics in...Applied Fluvial Geomorphology
Geol 631  Engineering Geomorphology
Geol 681  Seminar – Tools in Geomorphology
Wmhs 685  Applications and Problems in Hydrological Science

Students and Postdocs Advised (Five Years)

2005-present  Netra Regmi  PhD Student  2007-present  Kopila Paudel  MS Student
2006-present  Prakash Chundun  PhD Student  2008-present  Daynna Rodosovich  MS Student
2006-present  Kelin Zhuang  PhD Student  2008-present  Adam Lee  MS Student
2006-present  Malixole Soviti  PhD Student  2008-present  Tim Brunk  MS Student
2008-present  Kevin Gamahe  PhD Student  2009-present  Bree McClennen  MS Student
2009-present  Aneila Chamorrow  PhD Student  2009-present  Jacob Hundl  MS Student
2007-2009  Maria Sanchez  PhD Student  2006-2008  Timothy Cook  MS Student
2005-present  Eric Hesse  MS Student  2006-2008  Megan Meir  MS Student
Five Recent Publications

Five Influential Publications

Research Publications 150 refereed journal articles, 125 presentations at conferences, 251 citations

Selected Projects with Extramural Funding (Five Years)
Texas Water Development Board, Office of Sponsored Projects VPR Office, Formation and Development of Meanders on the Brazos River, Texas (Rates of Channel Migration in Relation to Discharge), June 2009-August 2010, $40,000, Co-PI J.R. Giardino and A.A. Lee, MS Student.

Service and Professional Activities (Selected, Five Years)
1988-present Water Management and Hydrological Science, Texas A&M University
2008-present Director, G-Camp
2008-present Publications Chair for Engineering Geology Division, Geol. Soc. Amer.
1996-present Editorial Board, Geomorphology
2004-2007 Member of Geoscience Education Division, Geological Society of America
2000-2007 Chair of Texas A&M University System Council of Graduate Deans
CURRICULUM VITAE
Richard Gibson, Associate Professor

Ph.D. (Geophysics) Massachusetts Institute of Technology, 1991
B.Sc. (Geology) Summa cum Laude, Baylor University, 1985

Professional Experience
2000-present  Associate Professor, Geophysics, Texas A&M University
1997-2000  Assistant Professor, Geophysics, Texas A&M University
1994-1996  Research Scientist, Earth Resources Laboratory, M.I.T.
1992-1994  Post-doctoral associate, Earth Resources Laboratory, M.I.T.
1991-1992  Post-doctoral research, Université Joseph Fourier, Grenoble, France

Honors and Awards
2009  Francesco Paolo di Gangi/Heep Professor
2006  Practice Award, The Decision Analysis Society of the Institute for Operations Research and the Management Sciences
2004  College-Level Distinguished Teaching Award, Texas A&M
2000  A.I. Levorsen Award, best paper at Gulf Coast Assoc. Geol. Soc. Meeting,
1993  Sigma Xi Scientific Research Society
1992  Best Paper Honorable Mention, 1992 SEG Annual Meeting
1986-1990  National Science Foundation Fellowship

Courses Taught (Five Years)
GEOL 101H  Principles of Geology
GEOP 655  Borehole Acoustics
GEOP 652  Earthquake Seismology
GEOP 651  Theoretical Seismology
GEOP 629  Seismic Interpretation

Students and Postdocs Advised (Five Years)
2000-present  John Priest  PhD student  Texas A&M
2007-present  Rituparna Basu  PhD student  Texas A&M
2009-present  Zhonghai Liu  MS Student  Texas A&M
2009-present  Bo Chen  MS Student  Texas A&M
2009-present  Kai Gao  PhD Student  Texas A&M
2009-present  Dehan Zhu  PhD Student  Texas A&M
2009-present  Au Vuong  PhD Student  Texas A&M
2009-present  Jiangchao Ge  PhD Student  Texas A&M
2007-2009  Kyubum Hwang  MS Student  Korea Gas Corporation
2006-2009  Hoa Quang Bui  PhD Student  BP
2003-2008  Ravi Shekhar  PhD Student  ExxonMobil
2002-2007  Seung Choo Yoo  PhD Student  Ion Geo (GTX)
2001-2007  Hung Liang Lai  PhD Student  Seismic MicroTechnology
2003-2006  Paula Clark  MS Student  deceased
2001-2005  Kyoung Jin Lee  PhD Student  BP
2003-2005  Necdet Karakurt  MS Student  (in Turkey)
2003-2005  David Barnett  MS Student  Anadarko
Five Recent Publications

Five Influential Publications

Research Publications 25 refereed journal articles, 4 technical articles, 7 proceedings and transactions, 70 presentations at national and international conferences.

Selected Projects with Extramural Funding (Five Years)
DOE-DE-FC26-02NT15342, Development of advanced seismic evaluation processes for hydrocarbon fluid saturation in deep water reservoirs, 9/1/2002-8/31/2005, $750,000 ($265,789 to Texas A&M), (PI: Michael Batzle, Colorado School of Mines, co-PI: De-hua Han, Univ. of Houston, Paradigm Geophysical Inc. is a partner also).
CURRICULUM VITAE
Ethan L. Grossman, Professor and Halbouty Chair

Ph.D. (Geochemistry, T-L. Ku, advisor), Univ. of Southern California, 1982
B.S. (Geology—magna cum laude), SUNY at Albany, 1976

Professional Experience
2002-present Mollie B. and Richard A. Williford Professor, Dept. of Geology & Geophysics
8/2007-8/2008 Acting Executive Associate Dean and Associate Dean for Research
6/2008-8/2008 Acting Deputy Director of Science Services, Integrated Ocean Drilling Program (IODP)-US Implementing Organization (USIO)
1994-2002 Professor, Texas A&M University, Dept. of Geology & Geophysics
1988-94 Associate Professor, Texas A&M University, Department of Geology.
1982-88 Assistant Professor, Texas A&M University, Department of Geology.
1981-82 Instructor, California State Univ. Northridge, Department of Geosciences.

Honors and Awards
2009 Michel T. Halbouty Chair in Geology
2007 Elected Fellow of the Geological Society of America
2005 Dean's Distinguished Achievement Award for Faculty Research, College of Geosciences
2002 Awarded Mollie B. and Richard A. Williford Professorship

Courses Taught (Five Years)
GEOL 101 Principles of Geology
GEOL 648 Stable Isotope Geology
GEOL 658 Earth Systems through Deep Time (team taught, lead)
GEOL 689 Special Topics in Geochemical Characterization of Natural Systems (team taught)
CHEM 685 Molecular View of the Environment, Info. Technology in Science (team taught)

Students and Postdocs Advised (Five Years)

Five Recent Publications (*student author)

Five Influential Publications (*student author)


Research Publications 41 refereed journal articles, 3 refereed book chapters and articles, 11 non-refereed publications, articles and conference proceedings, 108 presentations at national and international conferences. 1886 total citations (11/1/09)

Selected Projects with Extramural Funding (Five Years)


NSF (EAR-0643309). Carboniferous chemostratigraphy: Do epicontinental seas reflect global ocean conditions? Thomas, Grossman, Miller, Olszewski, Yancey, 1/1/08-12/31/10, $290,801.

NSF (EAR-0524285). The CHRONOS System: Geoinformatics for Deep-time Earth Processes, Subcontract through Iowa State University, E. Grossman, 8/1/05-7/31/07, $35,000 (C. Cervato, PI with 7 subcontractors; total = $1.1M).

NSF (EAR-03152216). CHRONOS Network for Earth System History: Development of Integrated Databases, Portals and Toolkits, Subcontract through Iowa State University, E. Grossman, 8/1/03-7/31/07, $50,194 (C. Cervato, PI with 14 co-PIs; total = $1.7M) (Also received $35,000 to organize CHRONOS's Geochemical Cycles Workshop).

NSF (EAR-0321278). MRI: Acquisition of Stable Isotope Facilities for Geologic Research at Texas A&M University E. Grossman, 8/15/03 - 7/31/05, $252,907.

Service and Professional Activities (Selected, Five Years)


1998- present Associate Editor, PALAIOS (Journal of the Society for Sedimentary Geology)

2007 Theme session co-organizer (E.L. Grossman and H-S. Mii) and plenary speaker, XVI Intl. Congress on the Carboniferous and Permian, Nanjing, China

2002-2006 Participant, CHRONOS Project (sedimentary geochemistry database and tools)

2004-2006 Internal Coordinating Committee, NSF-funded CHRONOS Project

2005 Steering Committee and speaker, NSF-sponsored workshop on Environmental Proxies, San Francisco (“Geoinformatics: What emerging IT systems can do for you”)


2007-present Member, Advisory Committee of Environmental Programs in Geosciences, TAMU

1994-2007 Member (chair 1998-2004), Departmental Tenure and Promotion Committee
CURRICULUM VITAE

Renald Guillemette, Research Associate Professor

Ph.D. (Geology) Stanford University, 1983, M.Sc. (Geology) Brown University, 1975, B.S. (Geology), Rensselaer Polytechnic Institute, 1973

Professional Experience

2007-present Research Associate Professor, Geology & Geophysics, Texas A&M University
1990-2007 Associate Research Scientist, Geology and Geophysics, Texas A&M University
1989-1990 Research Instrumentation Specialist, Geology, Texas A&M University
1982-1989 Assistant Professor of Geology, Southern Illinois University at Carbondale
1981-1982 Electron Microprobe Operator and Instructor, School of Earth Sciences, Stanford University
1975-78 Research Associate and Instructor, Geology and Geophysics, Boise State University

Honors and Awards

1997 TAMU College of Geosciences Award for Outstanding Research Support

Courses Taught (Five Years)

Geol 643 Introduction to Electron Microprobe Analysis
Geol 689 Electron Microprobe Analysis
Geol 689 Special Topics in Geochemical Characterization of Natural Systems (co-taught)

Students and Postdocs Advised (Five Years)

2005-2006 Shirley Dawn Hart (co-chair) MS Student Texas A&M

Five Recent Publications


Five Influential Publications


**Research Publications** 1 refereed invited book chapter, 11 refereed journal articles, 2 articles and conference proceedings publications, 21 presentations at national and international conferences.

**Service and Professional Activities (Selected, Five Years)**

- 2004-present Co-chair, Department Microprobe Committee
- 2004-present Member, Department Computer Committee
- 2005-2006 Member, College of Geosciences Research Professionals Committee
CURRICULUM VITAE
Andrew Hajash, Professor of Geology

Ph.D. (Geology) Texas A&M University, 1975
M.S. (Geophysics) Florida State University, 1970
B.S. (Geology), Florida State University, 1969

Professional Experience
1993-present Professor of Geology and Geophysics, Texas A&M University
1999-2003 Head of Department of Geology and Geophysics, Texas A&M University
1996-1998 Assistant Department Head, Geology and Geophysics, Texas A&M University
1981-1993 Associate Professor of Geology, Texas A&M University
1975-1981 Assistant Professor of Geology, Texas A&M University

Honors and Awards
2009 American Rock Mechanics Association Research Award
2003 David B. Harris Chair in Geology, Texas A&M
2002 Distinguished Achievement Award in Teaching (TAMU, University Level)
1982 Geosciences Distinguished Teaching Award (TAMU, College Level)
1974 Travel Grant to International Woollard Symposium, Honolulu, Hawaii

Courses Taught (Five Years)
Geol 101 Principles of Geology
Geol 104 Physical Geology
Geol 302 Introduction to Igneous, Metamorphic, and Sedimentary Petrology
Geol 330 Geology Field Trips: Big Bend
Geol 330 Geology Field Trips: Western United States
Geol 330 Geology Field Trips: Death Valley, California
Geol 330 Geology Field Trips: New Mexico, Colorado

Students and Postdocs Advised (Five Years)
2007-present Nick Groves MS Student Texas A&M
2004-2008 Woodong Jung Ph.D. Student Texas A&M
1975-present 6 Ph.D. Students 21 MS Students 1 Post Doc

Five Recent Publications
Five Influential Publications


Research Publications 23 refereed journal articles, 6 conference proceedings, 2 chapters in books, 69 presentations at national and international conferences. 701 total citations

Service and Professional Activities (Selected, Five Years)

2009 Member, Graduate Recruiting and Admissions Committee (charged to coordinate awards of fellowships/scholarships)

2008-present Member, Program Assessment Committee

2007-present Chair, Undergraduate Advising Committee

2007-present Member, Department Seminar Committee

2006 Chair, University Selection Committee, AFS Distinguished Achievement Awards (Individual Student Relations)

2006-2008 Member, Faculty Advisory Committee to the Vice President for Student Affairs

2004 Member, University Selection Committee, AFS Distinguished Achievement Awards
CURRICULUM VITAE
Bruce E. Herbert, EOG Professor, Assistant Dept Head and Graduate Coordinator

Ph.D, M.S. (Soil Science) University of California, Riverside, 1992, 1988
B.S. (Chemistry) Colgate University, 1982

Professional Experience

2007-present Assist. Dept. Head and Graduate Coordinator, Geology & Geophysics.
2006-present Professor, Geology & Geophysics, Texas A&M University.
2004-present Texas Professional Geologist, License 3445.
2002-2007 Assoc. Director of Geosciences, Information Technol. in Science (TAMU ITS)
1998-2003 Coordinator of Undergraduate Programs, Geology & Geophysics, Texas A&M.
1997-2006 Associate Professor, Geology & Geophysics, Texas A&M
1992-97 Assistant Professor, Geology & Geophysics, Texas A&M
1982-84 Volunteer, U.S. Peace Corps, Taveuni, Fiji Islands, South Pacific.

Honors & Awards (Last Five Years)

2009 EOG Teaching Professor in Geosciences
2005-2009 Distinguished Lecturer, National Association of Geoscience Teachers
2006 Assessing Technology in Teaching Award, Office of Distant Education, TAMU
2003 College of Geosciences Distinguished Achievement Teaching Award
2001 Assoc. Former Students Distinguished Achievement Award in Teaching
2000 Robert C. Runnels Excellence in Advising (College-level award)

Courses Taught (Last Five Years)

GEOL 101 Physical Geology, (4 credits, undergraduate)
GEOL 311 Writing in the Geosciences, (1 credits, undergraduate)
GEOL 420 Environmental Geology, (3 credits, undergraduate)
GEOL 485 Directed Studies: Earth Science Education, (3 credits, undergraduate)
GEOL 485 Directed Studies: Geomicrobiology, (3 credits, undergraduate)
GEOL 485 Directed Studies: Visualization, (3 credits, undergraduate)
GEOL 641 Environmental Geochemistry, (3 credits, graduate).
GEOL 685 Organic Geochemistry (3 credits, graduate seminar)
GEOL 685 Professional Development and Proposal Writing (2 credits, graduate seminar)
GEOL 689 Geochemical Characterization of Natural Systems (3 credits, graduate)

Chair, Graduate Students (Last Five Years)

Current, PhD Nathan Gardiner, Clint Miller, Julie Johnston, Charita Ray-Blakely, PhD (Higher Education)
Current, MS Sinem Arten, Jayme Foster, Roberta McClure
2009 Li-Jung Kuo, Ph.D. Post-doctoral research associate, Pacific Northwest National Lab.
2009 Omar Harvey, Ph.D. (Water Management & Hydrology) Post-doctoral research associate, Texas Transportation Institute.
ABD Heather Miller, Ph.D. Asst. Professor, Grand Valley State, MI.
ABD Ron Parker, Asst. Prof., Earlham College; now with Fronterra Integrated Geosci. LLC
2007 Chris Markley, Nuclear Regulatory Agency
2007 Karen McNeal (Sell), Asst. Prof., Mississippi State University

28
Five Recent Publications (* student author)


Five Influential Publications (* student author)


Research Publications 39 refereed journal articles, 24 articles and conference proceedings publications, 90 presentations at national and international conferences. 319 total citations.

Selected Projects with Extramural Funding (Last Five Years)

NSF-CLT. The CIRTL Network - Shaping, Connecting, and Supporting the Future National STEM Faculty. 2008-2011. B. Matheiu U. Wisconsin), PI.; Co-PIs include B. Herbert (Texas A&M), Ann Austin (Michigan State), Patricia Rankin (U. of Colorado). $4.1 million ($472k, TAMU share).

Federal Highway Administration. Aggregate-asphalt interactions: Role of mineral surface chemistry, organic functional groups and competition with water. 2006-2011. Flexible Pavements Consortium (Western Research Institute (University of Wyoming), the Texas Transportation Institute (TAMU), the University of Wisconsin-Madison, University of Nevada-Reno and Advanced Asphalt Technologies, LLC at Sterling, Virginia). $57 million (Herbert share $300,000).


CURRICULUM VITAE

Luc T. Ikelle, Berg Professor

Ph.D.(Geophysics & Geochemistry) Institut de Physique du Globe de Paris, 1986
M.Sc.(Mathematics & Theoretical Physics) Institut de Physique du Globe de Paris, 1983

Professional Experience

2001-present  Professor of Geology and Geophysics, Texas A&M University
1997-2000  Associate Professor of Geology and Geophysics, Texas A&M University
1988-1997  Scientist, Schlumberger (UK, USA)
1987-1988  Postdoctoral Fellow, Cray Research USA

Honors and Awards

2002-present  Robert R. Berg Professorship in Geology
1986  Prix de These du CNRS

Courses Taught (Five Years)

Geop 421  Petroleum Seismology I
Geop 622  Petroleum Seismology II
Geop 623  Petroleum Seismology III

Students and Postdocs Advised (Five Years)

Dr. Ioan Sturzu  Postdoctoral Fellow
Xiujun Yang  PhD Student
Veronica Arrigoni  MS Student
Baba Tunde Gbadamosi  MS Student
Janelle Grenidge  MS Student
Nan Ma  MS Student
Oleksiy Pochivalov  MS Student
Au Vuong  MS Student
Zhanar Bailey  now with Devon Energy
Ilana Erez  now at Tel Aviv Univ
Kumar Singh  now at WesternGeco

Five Recent Publications

Five Influential Publications


Books


Research Publications

58 refereed journal articles, 113 presentations at national and international conferences. 203 total citations

Selected Projects with Extramural Funding (Five Years)


Service and Professional Activities (Selected, Five Years)

Member, Editorial Board, Journal of Seismic Exploration
Member, Advisory Board, WesternGeco
Advisor, SEG Student Chapter
Member, TAMU Geosciences without Borders
Manager of website Petroleumseismology.com
Manager of website CASP.tamu.edu
Manager of website RobertBerg.tamu.edu
CURRICULUM VITAE
Andreas Kronenberg, Professor and Head

Ph.D., M.S. (Geology) Brown University, 1983, 1979
B.S. (Geology), UCLA, 1977

Professional Experience

2007-present  Head of Department of Geology and Geophysics, Texas A&M University
1995-present  Professor of Geology and Geophysics, Texas A&M University
1989-present  Associate Director, Center for Tectonophysics
1990-1995  Associate Professor of Geophysics, Texas A&M University
1985-1990  Assistant Professor of Geophysics, Texas A&M University

Honors and Awards

2009  American Rock Mechanics Association Research Award
2009  EGU Keith Runcorn Travel Grant
2002-2007  Ray C Fish Professorship in Geology
1997  TAMU Geosciences Distinguished Research Award
1991  TAMU Geosciences Distinguished Teaching Award

Courses Taught (Five Years)

Geol 101  Principles of Geology
Geol 300  Field Geology
Geol 665  Structural Petrology
Geop 615  Experimental Rock Deformation
Geop 660  Physics of the Earth's Interior

Students and Postdocs Advised (Five Years)

2007-present  Caleb Holyoke III  Post-doctoral Fellow  Texas A&M
2002-2005  Nathan Davis  MS Student  Chesapeake Energy

Five Recent Publications


Five Influential Publications


Research Publications 42 refereed journal articles, 9 articles and conference proceedings publications, 78 presentations at national and international conferences. 1740 total citations

Selected Projects with Extramural Funding (Five Years)


Service and Professional Activities (Selected, Five Years)

2007-present San Andreas Fault Observatory at Depth (SAFOD) Core Sampling Committee
2006-2008 Chair, AGU Mineral and Rock Physics Fellows Nomination Committee
2006-2007 Chair, AGU Mineral and Rock Physics Student Awards Committee
2005 Editor, Physical Properties of Earth Materials (PPEM) Newsletter
2004-2007 Secretary, AGU Mineral and Rock Physics Executive Committee

2007-present Head, Department of Geology and Geophysics
2007-present Member, Executive Committee of the College of Geosciences
2005 TAMU Vice President of Research Committee on Pre-Award Services
2004-2007 Chair, Department Tenure and Promotion Committee
2001-2005 Chair, Microscopy and Imaging Center Advisory Committee
CURRICULUM VITAE
Will Lamb, Associate Professor

Ph.D. in Geology, University of Wisconsin, Madison, Wisconsin, U.S.A.
Dissertation: Metamorphic Fluids and Granulite Genesis, 1987
M.A. in Geology, Rice University, Houston, Texas, U.S.A., 1983
B.A. in Geology, Earlham College, Richmond, Indiana, U.S.A., 1980

Professional Experience:

1993-present  Associate Professor, Texas A&M University
             Metamorphic Petrology: Phase Equilibria, Fluid Inclusions, Stable Isotopes
1996-1997    Faculty Development Leave, Utrecht University, Utrecht, Netherlands
             Mantle Fluids and Deformation, Deformation of Fluid Inclusions
1987-1993    Assistant Professor, Texas A&M University

Courses Taught (Last Five Years)

Geology 101 Principles of Geology
Geology 304 Igneous and Metamorphic Petrology
Geology 689 Advanced Metamorphic Petrology
Geology 681 Seminar: Deep Crust and Mantle Dynamics

Graduate students advised:

Over the last five years I have served as a member on the committees of four students: Pablo Cervantes (Ph.D.), Astrid Rodriguez (M.S.), Rachel Wells (M.S.), and Kristen Mullen (M.S.).

Five Recent Publications (peer-reviewed journals)


Five Influential Publications


Research Publications: 29 refereed articles, 1 short course chapter, 2 scientific reports, 55 abstracts at national and international conferences, with a minimum of 996 citations.

Selected Projects (Five Years)

Mantle Fluids: Amphibole Equilibria and Mantle aH$_2$O: This research includes using H$_2$O-buffering phase equilibria to determine values of $f$H$_2$O (H$_2$O fugacity) in the mantle, and comparing these estimates of fH$_2$O with values determined using other techniques. Funding for this research includes a grant from the Texas Advanced Research Program ($95,050.00 – 1/1/02 to 12/31/03).

Measurement of the Ferric-Ferrous Ratio in Minerals using the Electron Microprobe (EMP): Equilibria involving Fe in minerals from the crust and mantle have been important in estimating values of T, P, and $f$O$_2$. However, the accuracy of these estimates often depends on determining the oxidation state of Fe in minerals. Given the relatively good spatial resolution and accessibility of the EMP, the proposed research will test different methods for determining $Fe^{3+}/Fe_{total}$ in certain minerals using this instrument.

The Thermophysical Properties of fluids in the CH$_4$ ± H$_2$O ± NaCl system as determined from synthetic fluid inclusions: This research was supported by the National Science W.M. Lamb and R.K. Popp co-P.I.’s., EAR 9405629, 9/1/94 to 8/31/98 $100,363 and EAR 9117735 1/15/92 to 12/31/94 $45,359

Service and Professional Activities (Selected, Five Years)

2007-present Member, Executive Committee, Department of Geology & Geophysics
1988-present Head, Electron Microprobe Committee, Department of Geology & Geophysics
2005-present Member, Curriculum committee, Department of Geology & Geophysics
2007-2009 Member, Halbouty Space Utilization Committee, Dept. of Geology & Geophysics
Franco Marcantonio, Associate Professor

Ph.D. (Geological Sciences), Columbia University, 1994
M.S. (Geology) McMaster University, 1988
B.S. (Chemistry and Geology) Carleton University, 1986

Professional Experience

2006-present  Associate Professor of Geology, Texas A&M University
2002-2006  Associate Professor of Geology, Tulane University
1996-2002  Assistant Professor of Geology, Tulane University
1995-1996  Post-doctoral research associate, Yale University
1994-1995  Post-doctoral research scientist, Columbia University

Honors and Awards

2003  Mortar Board Award for Teaching Excellence at Tulane University
1997-2006  Member of the Speaking of Science Program (Louisiana BoRSF)
1998  Oak Ridge Associated Universities Junior Faculty Enhancement Award

Courses Taught (Five Years)

Geol 101  Principles of Geology
Geol 311  Principles of Geological Writing
Geol 451  Geochemistry
Geol 685  Teaching Assistant Course
Geol 685  Analytical Geochemistry Methods Course
Geol 689  Radiogenic Isotope Geochemistry

Students Advised (Five Years)

2007-present  Ajay Singh  PhD  Texas A&M
2007-present  Ruifang Xie  PhD  Texas A&M
2009-present  Bree McClenning  MS  Texas A&M
2001-2006  Ali Pourmand  PhD  Tulane University
2004-2006  David McGee  MS  Tulane University
2004-2006  Troy Grzymko  MS  Tulane University
1999-2004  Yingfeng Xu  PhD  Tulane University

Five Recent Publications


Five Influential Publications


Research Publications 31 refereed journal articles, 58 presentations at national and international conferences. 819 total citations

Selected Projects with Extramural Funding (Five Years)

NSF-OCE-0851056, $^{230}$Th dynamics in the Eastern Equatorial Pacific Ocean: testing the $^{230}$Th-normalization method to estimate sediment fluxes, July 1, 2009 - June 30, 2012, $401,841$, (co-PI Dr. M. Lyle—Oceanography, TAMU).


State of Louisiana CREST, Quantifying Subsidence in Barataria Bay and Surrounding Areas and its Impact on Recent Bay Evolution, July 1, 2006-June 30, 2008, $74,000$, (PI Dr. M. Allison—UTIG).


Service and Professional Activities (Selected, Five Years)

2008- member of Geotraces international intercalibration study of seawater isotopes
2009- member, College of Geosciences Climate and Energy START Committee
2009- member, College of Geosciences AFS Faculty Award Selection Committee
2007- member, College of Geosciences Faculty Committee
2007- member, Departmental Tenure and Promotion Committee
2006-2007 member, search committee, Department Head for the Department of G & G
CURRICULUM VITAE

Christopher C. Mathewson, Regents Professor

PhD, (Geological Engineering), University of Arizona, 1971
MS, (Geological Engineering), University of Arizona, 1965
BS, (Civil Engineering), Case Institute of Technology, 1963

Professional Experience

2006-present: Named “Regents Professor”, Texas A&M University
1982-present: Professor (Engineering Geology), Geology and Geophysics. TAMU
1982-1996: Director, Center for Engineering Geosciences.
1992 June-August: WES Graduate Institute, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
1988 June-August: WES Graduate Institute, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
1977-1978: Director, Center for Applied Geosciences, College of Geosciences.
1976-1982: Associate Professor, (Engineering Geology), Department of Geology, TAMU
1971-1976: Assistant Professor, (Engineering Geology), Department of Geology, TAMU.
1966-1970: Lieutenant, National Ocean Survey, Department of Commerce

Honors and Awards

2008 Karl and Ruth Terzaghi Outstanding Mentor Award, Association of Environmental and Engineering Geologists.
2007 Pete Henley Mentor Award, Texas Section, Association of Environmental and Engineering Geologists.
2006 Regents Professor, Texas A&M University System
2006 Robert C. Runnels Excellence in Advising Award, Geosciences, TAMU
2006 Life Member, American Society of Civil Engineers
2006 Fellow, Society of American Military Engineers
1995 Floyd T. Johnston Service Award, Association of Engineering Geologists
1991 Meritorious Service Award, Engineering Geology Division, GSA.
1986 Faculty Distinguished Achievement Award in Teaching TAMU
1981 Claire P. Holdredge Award, Association of Engineering Geologists

Courses Taught (Five Years)

Geol 301 Mineral Resources (5 times)  Geol 440 Engineering Geology (5 times)
Geol 308 Integrated Earth Science (9 times)  Geol 485 Special Studies (Undergraduate Research)
Geol 320 Geology for Civil Engineers (9 times)  Geol 610 Field Methods in Hydrogeology (3 times)
Geol 330 Geology Field Trips (8 times)  Geol 635 Engineering Geology (3 times)
  Geol 981 Seminar (1 time)

Students and Postdocs Advised (Five Years) at Texas A&M University

2010 Kolkmeier, B., Master of Science
2005 Allison, J.B., Master of Science.
2005 Bell, J. C., Master of Science.

Undergraduate Advisor, Geology and Engineering Geology Option

Five Recent Publications
My recent publication activity has been related to adult education and continuing professional education, samples of this work are listed below:


Five Influential Publications


Research and Teaching Publications 24 refereed journal articles, 97 articles, editorials, guidebooks and conference proceedings publications, 451 presentations at national/international conferences, universities, short courses and public meetings.

Selected Projects with Extramural Funding (Five Years)
My professional emphasis changed over the past five years toward teaching and educational outreach. Total career funding for research totals $2,192,709 for 92 funded projects.

Service and Professional Activities (Selected, Five Years)
2004-2012: Aggie Honor Council
1988-Present: Academic Mentor, Texas A&M University Corps of Cadets

I have extensive professional service, including President, Editor, Foundation Trustee, etc
1994-present National Association of State Boards of Geology, National Council of Examiners
2005-Present American Association of Petroleum Geologists, Field Trip Safety Committee,
CURRICULUM VITAE
Brent V. Miller, Associate Professor

Ph.D. (Geology) Dalhousie University, 1997; M.Sc., B.Sc, Ohio University, 1991, 1987

Professional Experience
2008-present Associate Professor, Geology and Geophysics, Texas A&M University
2005-2008 Assistant Professor, Geology and Geophysics, Texas A&M University
2004-2005 Research Scientist, Geology and Geophysics, Texas A&M University
1999-2004 Research Assistant Professor, University of North Carolina
1996-1999 Post-Doctoral Research Fellow, Syracuse University

Honors and Awards
1991 Outstanding Thesis Award, Ohio University

Courses Taught (Five Years)
Geol 101 Physical Geology
Geol 104 Principles of Geology
UPAS 181 Freshman Seminar
Geog 203 Physical Geography
Geol 300 Field Geology
Geol 311 Principles of Scientific Writing
Geol 451 Geochemistry
Geol 645 Geochronology
Geol 685 Radiogenic Isotope Lab Methods
Geol 689 Radiogenic Isotope Geochemistry

Students and Postdocs Advised (Five Years)
2006-present Brent Barley, Ph.D., Texas A&M University
2004-2007 Ayoti Ghosh, Ph.D., Texas A&M University
2004-2006 Jeff Pollock, Ph.D., North Carolina State University

Five Recent Publications
Five Influential Publications


Research Publications 43 refereed journal articles, 1 short course publication, 92 presentations at national and international conferences, 206 citations

Selected Projects with Extramural Funding (Five Years)


NSF MRI, Acquisition of a High Resolution Inductively Coupled Plasma Mass Spectrometer for Earth and Environmental Science Research at Texas A&M University, NSF MRI, 0821455. Collaborative with Franco Marcantonio, Ethan L Grossman, Matthew W Schmidt, Deborah J Thomas. Total Project $450,000.

NSF EAR, Tectonothermal History of the Acatlán Complex, Southern Mexico: A Record of the Closure of the Rheic Ocean? (2003) National Science Foundation, $144,934 (total project $252,747); collaborative with Damian Nance, Ohio Univ.

Service and Professional Activities (Selected, Five Years)

2009-Present  Ohio University Alumni Advisory Board
2008-Present  College Undergraduate Scholarships Committee
2008-Present  Radiation Safety Officer for Radiogenic Isotope Laboratory
2007-Present  Brazos Valley Museum Natural History – Science Advisor, Exhibit Development
2007-Present  Graduate Program Enhancement Committee
2006-Present  Undergraduate Advisors Committee
2005-Present  Radiogenic Isotope Facility Oversight Committee
2006-2008  Graduate Student Council Faculty Advisor
CURRICULUM VITAE

Kate C. Miller, Professor and Dean of Geosciences

Ph.D., M.S. (Geophysics) Stanford University, 1991, 1988
A.B. (Geological & Geophysical Sci) Magna cum Laude, Princeton Univ, 1982

Professional Experience

2009-present  Dean of College of Geosciences, Texas A&M University
2009-present  Professor of Geology and Geophysics, Texas A&M University
2004-2008  Assoc Dean, College of Science, University of Texas, El Paso
2002-2009  Professor, Department of Geological Sciences, University of Texas, El Paso
1998-2004  Chair, Department of Geological Sciences, University of Texas, El Paso
1998-2002  Associate Professor, Dept Geological Sciences, University of Texas, El Paso
1993-1998  Assistant Professor, Dept Geological Sciences, University of Texas, El Paso
1992-1993  Visiting Assistant Professor, Dept Geological Sci, University of Texas, El Paso

Honors and Awards

2001  Chancellor's Council Outstanding Teaching Award, University of Texas
1997  Fellow, Geological Society of America
1982  Sigma Xi

Courses Taught (Five Years)

- Introduction to Earth Science I & II
- Introduction to Historical Geology
- Exploration Geophysics: Seismic Methods
- Geophysical Applications of Digital Signal Processing
- Seismic Reflection Data Interpretation
- Modeling and Inversion of Wide-Angle Seismic Data
- Geophysical Framework of North America
- Applications of Inverse Theory
- Advanced Seismology

Students and Postdocs Advised (Five Years)

<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
<th>Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>J. C. Chang</td>
<td>MS Student</td>
</tr>
<tr>
<td>2008</td>
<td>O. Dena</td>
<td>PhD Student</td>
</tr>
<tr>
<td>2007</td>
<td>M. Averill</td>
<td>PhD Student</td>
</tr>
<tr>
<td>2005</td>
<td>O. Elebiju</td>
<td>MS Student</td>
</tr>
</tbody>
</table>

Five Recent Publications


**Five Influential Publications**


**Research Publications** 49 refereed journal articles, 5 articles and conference proceedings publications, 27 presentations in last 5 years at national and international conferences. 208 total citations

**Selected Projects with Extramural Funding (Five Years)**


Shell Oil, Support for Pathways Summer Program, Feb. 2005-Feb 2010, $75,000.


THECB, STAR Award for Seismic Instrumentation, June 2005-Feb. 2006, $200,000, CoPI Doser, Keller.
CURRICULUM VITAE
Julie Newman, Assistant Professor

Ph.D., M.S. (Geological Sciences) University of Rochester, 1993, 1990
B.A. (Geology), Oberlin College, 1985

Professional Experience
2005-present  Assistant Professor, Geology and Geophysics, Texas A&M University
1998-2005  Lecturer; Research Scientist (part-time positions), Geology and Geophysics;
Microscopy and Imaging Center, Texas A&M University
1995-1998  Postdoctoral Research Associate, Vening Meinesz Research School of
Geodynamics, Utrecht University, The Netherlands
1993-1995  Postdoctoral Research Fellow, Geology and Geophysics, Texas A&M University

Courses Taught (Five Years)
Geol 101-Honors  Principles of Geology
Geol 312  Structural Geology
Geol 312-W  Structural Geology as Writing within the Curriculum Course
Geol 311  Principles of Geologic Writing
Geol 689  Interpretation of Naturally Deformed Microstructures
Geol 685  Deformation and Metamorphism in Nature
Geol 689  Fundamentals of Scanning Electron Microscopy

Students and Postdocs Advised (Five Years)
2007  Virginia Toy  Postdoctoral Fellow  University of Otago, NZ
       (assistant professor)
2007-present  Astrid Rodriguez  MS Student  Texas A&M
2007-present  Rachel Wells  MS Student  Texas A&M
2006-present  Kristen Mullen  MS Student  Texas A&M
2002-2005  Nathan Davis  MS Student  Chesapeake Energy
2009  Stephanie Ford  Undergraduate  Texas A&M
2006-2007  Michael McGroarty  Undergraduate  Texas A&M

Five Recent Publications
of shear localization. *Journal of Petrology.*
the seismic properties of oceanic gabbros. *Geochem. Geophys. Geosyst.* 10, Q03O16,
zones in mantle rocks: Evidence from alpine and ophiolitic peridotite massifs. In: (ed. Alsop, G,
Five Influential Publications


Research Publications  •  16 refereed journal articles, 1 book chapter, 43 presentations at national and international conferences. 170 total citations

Selected Projects with Extramural Funding (Five Years)


NSF-EAR-0409567, *Collaborative Research: Determining mantle rheology from field and microstructural observations of naturally-deformed peridotites*, July 1, 2004 – June 30, 2007, extended to Dec. 31, 2009, $89,000 (TAMU budget), collaborative with Dr. B. Tikoff, University of Wisconsin-Madison and Dr. T. Little, Victoria University, Wellington, New Zealand.


Service and Professional Activities (Five Years)

2009  •  Member, organizing committee, Tectonics Structural Geology meeting, May, 2009, Madison, WI

2005-present  •  Graduate Committee, Department of Geology and Geophysics, TAMU

2005-2008  •  ODASES committee, College of Geosciences, TAMU

2006-2007  •  Faculty Search Committee (ODASES/Reinvestment: 4 positions), Department of Geology and Geophysics, TAMU

1998-present  •  Electron Microprobe Committee, Department of Geology and Geophysics, TAMU

2005 – present  •  K-12 volunteer (lectures and activities on plate tectonics, rocks and minerals, earthquakes), Bryan-College Station
CURRICULUM VITAE
Thomas Olszewski, Associate Professor

Ph.D. (Geosciences) The Pennsylvania State University, 2000
M.S. (Geology) Kansas State University, 1994
B.A. (Geology) Franklin and Marshall College, 1990

Professional Experience
2008-present Associate Professor, Geology and Geophysics, Texas A&M University
2003-2008 Assistant Professor, Geology and Geophysics, Texas A&M University
2002-2003 Visiting Scientist, Paleobiology, National Museum of Natural History
2000-2001 Postdoctoral Fellow, Geological Sciences, Indiana University-Bloomington

Honors and Awards
2009 Paleontological Society Schuchert Award Winner
2005-2006 TAMU Center for Teaching Excellence Montague Scholar
2004 Outstanding Paper Award in Palaios
2001 Outstanding Paper Award in Palaios

Courses Taught (Five Years)
GEOL 101 Principles of Geology
GEOL 305 Paleobiology
GEOL 689 Paleontological Community Analysis (permanent number: 651)
GEOL 689 Earth Science Modeling (co-taught with D.Sparks; requested number 678)
GEOL 689 Geobiological Research Methods (co-taught with M.Tice)
GEOL 609 Field Geology (Book Cliffs Field Trip)

Students and Postdocs Advised (Five years)
2007-present Jason Moore Harris Postdoctoral Fellow Texas A&M
2006-present Cory Redman PhD Student Texas A&M
2004-present Leigh Fall PhD Student Texas A&M
2004-2006 Danielle Ebnother MS Student Encana Corporation
2004-2006 Stephen Lichlyter MS Student Rosetta Resources

Five Recent Publications
Five Influential Publications


Research Publications 18 refereed journal articles, 1 articles and conference proceedings publications, numerous presentations at national and international conferences. 418 total citations

Selected Projects with Extramural Funding (Five Years)


NSF-EAR-0643309, *Carboniferous Chemostratigraphy: Do Epicontinental Seas Reflect Global Ocean Conditions?* October 1, 2007 - September 31, 2010, $290,801, PI: Dr. D. Thomas; Co-PIs: Dr. E. Grossman, Dr. B. Miller, Dr. T. Yancey.

Service and Professional Activities (Selected, Five Years)

2009-present Paleontological Society Program Coordinator

2009 National Science Foundation Review Panelist

2008 Co-convener for Topical Session, Geological Society of America National Meeting

2006 Ordanized and Edited Paleontological Society Short Course on Geochronology

2004-present Faculty Co-advisor to Texas A&M Geology and Geophysics Society

2003-present Associate Editor for Palaios

2006-2007 Member, Sedimentary Geology Search Committee

2005-2006 Member, Reinvestment/ODASES Search Committee
CURRICULUM VITAE

Michael C. Pope, Associate Professor

Ph.D., Virginia Tech, 1995
M.S. (Geology) University of Montana, 1989
B.S. (Geology), UCLA, 1985

Professional Experience

2009-present  Associate Professor of Geology and Geophysics, Texas A&M University
2005-2009  Associate Professor of Geology, Washington State University
1999-2005  Assistant Professor of Geology, Washington State University
1998-1999  Research Scientist, Mobil Oil Company, Dallas
1995-1998  Postdoctoral Fellow, Massachusetts Institute of Technology

Honors and Awards

2008  Voted Fellow in Geological Society of America
1993  GSA Sedimentary Division, Outstanding Research Proposal

Courses Taught (Five Years)

Geol 102 (WSU)  Physical Geology for Engineers and Scientists
Geol 210 (WSU)  Historical Geology
Geol 221 (WSU)  Field Trip
Geol 230 (WSU)  Oceanography
Geol 308 (WSU)  Field Geology II
Geol 421(WSU)  Stratigraphy
Geol 523 (WSU)  Seismic and Sequence Stratigraphy
Geol 525 (WSU)  Carbonate Sedimentology and Stratigraphy
Geop 628 (TAMU)  Basin Architecture

Students and Postdocs Advised (Five Years)

2002-2006  Kelly Dilliard  Ph.D Student  Wayne State College
2005-2007  Patrick Cabbage  M.S. Student
2006-2009  Eric Baar  M.S. Student  Barrick Mining Corporation
2003-2009  Sarah Huson  Ph.D Student  ExxonMobil

Five Recent Publications


Five Influential Publications


Research Publications 36 refereed journal articles, 3 articles and 3 field trip guidebooks, 55 presentations at national and international conferences. 190 total citations

Selected Projects with Extramural Funding (Five Years)

NSF EAR-0230008, *Distinguishing Regional Tectonic and Global Eustatic Events in Chesterian Rocks of East-Central Idaho and Southwestern Montana*, January 1, 2003- December 31, 2005, $128,714, Co-PI’s Dr. Isabel Montanez (UCDavis), Dr. Peter Isaacson (Univ. of Idaho).

NASA 05-PGG05-99, *Quantitative Analysis and Deformational history and timing of the Sierra Madera impact structure, west Texas*, July 9, 2006-July 10, 2009, $258,678, Co-PI’s Dr. John Watkinson (WSU) and Dr Nick Foiit (WSU)

EDMAP (United States Geological Survey), *Geologic Mapping of Portions of the Snaky Canyon, Shamrock Gulch, Copper Mountain, and Scott Butte 7.5 Minute Quadrangles, south-central Idaho*, June 1, 2006 – May 31, 2007 $10,500, Co-PI Dr. John Watkinson (WSU)

NSF EAR-0744393, *Technician Support (Years 4 and 5) for the Radiogenic Isotope and Geochronology Facility, Washington State University*, February 1, 2008-January 31, 2010 $90,000, Co-PI’s Dr. John Wolff (WSU) and Dr. Jeff Vervoort (WSU)

Service and Professional Activities (Selected, Five Years)

2005 2nd Vice-Chair, Sedimentary Geology Division, Geological Society of America
2006 1st Vice-Chair, Sedimentary Geology Division, Geological Society of America
2007 Chair, Sedimentary Geology Division, Geological Society of America
CURRICULUM VITAE
Robert K. Popp, Professor

Ph.D., M.S. (Geology), Virginia Polytechnic Institute & S.U., 1975, 1971
B.S. (Geology), Southern Illinois University, 1968

Professional Experience
1995-present  Professor of Geology, Texas A&M University
1999-2007  Assistant Head & Graduate Advisor, Geology & Geophysics, TAMU
1993-1999  Graduate Advisor, Department of Geology & Geophysics, TAMU
1990-1998  Visiting Scientist & CHiPR Research Collaborator, Geophysical Laboratory, Washington DC
1985-1995  Associate Professor of Geology, Texas A&M University
1979-1985  Assistant Professor of Geology, Texas A&M University
1976-1979  Postdoctoral Fellow, Geophysical Laboratory, Washington, DC

Honors and Awards
2004  TAMU Geosciences Distinguished Teaching Award

Courses Taught (Five Years)
Geol 101  Principles of Geology
Geol 203  Mineralogy
Geol 300  Field Geology
Geol 330  Geologic Field Trips
Geol 451  Geochemistry

Five Recent Publications

Five Influential Publications


**Research Publications** 37 refereed journal articles, 16 Geophysical Laboratory Yearbook articles, 1 book chapter, 48 presentations at national and international conferences. 917 total citations.

**Service and Professional Activities (Selected, Five Years)**

- **2007-2009** Member, Texas A&M University Fieldwork Safety Committee
- **2005-2009** Chair, Texas A&M University International Student Scholarship Committee
- **2005-2009** Member, Texas A&M University Scholarship Committee
- **1999-2007** Assistant Head & Graduate Advisor, Geology & Geophysics, TAMU
- **1995-2007** Member, Texas A&M University Graduate Council
- **1993-1999** Graduate Advisor, Department of Geology & Geophysics, TAMU
CURRICULUM VITAE
Anne Raymond, Professor

Ph. D. (Geophysical Sciences), University of Chicago, 1983
A. B. (Geology), Harvard University, 1977

Professional Experience
1996-present  Professor, Dept. of Geology & Geophysics, Texas A&M University
1988 - 1996  Associate Professor, Department of Geology, Texas A&M University
1983 - 1988  Assistant Professor, Department of Geology, Texas A&M University

Honors and Awards
2009  TAMU Association of Former Students, College of Geosciences Teaching Award
2003-2008  Earl Cook Professor of Geosciences
1988  TAMU Association of Former Students, College of Geosciences, Teaching Award
1986-1989  Mary Ingraham Bunting Science Fellowship, Harvard University
1977-1981  NSF Graduate Fellowship
1977-1981  University of Chicago Robert C. McCormick Fellowship

Courses Taught (Five Years)
Geology 101  Principles of Geology
Geology 106  Historical Geology
Geology 307  Dinosaur World
Geology 650  Paleocoeology
Geology 654  Evolutionary Patterns and Processes
Geology 658  Earth Systems through Deep Time

Students and Postdocs Advised (Five Years)
2009  Shih-Yi Hsiung  M.S. student  Texas A&M
2008 - present  Sikhar Banerjee  M.S. student  Texas A&M
2005 - 2007  Meaghan Julian  M.S. student  teaching in Vermont
2005 - 2007  Rachael McCarty  M.S. student  Chevron, Houston, TX
2004 - 2007  Lisa Williamson  M.S. student  Utah State (Ph.D. student)
2004 - 2006  Ben Eckstein  M.S. student  working in Cincinnati, OH
1997 - 2005  Paul Cutlip  Ph.D. student  St. Petersburg College, FL
2004 - 2005  Stephen Lichlyter  M.S. student  changed advisor to T. Olszewski

Five Recent Publications
* denotes student or former student co-author
DOI:10.1016/j.revpalbo.200903.007.


**Five Influential Publications**


**Research Publications** 36 refereed journal articles, 3 encyclopedia articles and open file reports, 77 presentations at national and international conferences, 610 citations.

**Selected Projects with Extramural Funding (Five Years)**


CO-PI's E. Powell, K. Hubbard, S. E. Walker, C. E. Brett, G. Staff, W. R. Callendar

1995-2000 NSF Collaborative Research: Global Phytogeography of the Early/Late Carboniferous, $142,000.00.

**Service and Professional Activities (Selected, Five Years)**

2009-present DETELO Steering Committee (NSF-sponsored, to increase geobiology funding)

2000-present Paleobiology Database, Paleobotany working group member

2005-present Associate Editor, International Journal of Coal Geology

2007-present College of Geosciences Tenure and Promotion Committee

2008-present Steering Committee, Texas A&M Women's Faculty Network
CURRICULUM VITAE
John H. Spang, Professor

Ph.D., M.S. (Geology), Brown University, 1971, 1967
B.S. (Geology), Denison University, 1965

Professional Experience

2006-2007  Interim Head, Department of Geology & Geophysics, Texas A & M University
1985-1993  Head, Department of Geology, Texas A & M University
1984-1985  Associate Director, Center for Tectonophysics, Texas A&M University
1983-present Professor of Geology, Texas A&M University
1980-1983  Associate Professor of Geology, Texas A&M University
1976-1980  Associate Professor of Geology, University of Calgary
1970-1976  Assistant Professor of Geology, University of Calgary
1976       Visiting Research Geologist, Cities Service Oil Co. Research Lab, Tulsa, OK
1998       Visiting Professor, International Expl., Texaco Expl. Inc., Houston (Summer)
1999       Visiting Geoscientist, Vastar Resources Inc., Houston (Summer)
2001       Visiting Geoscientist, ExxonMobil Producing Co., Houston (Summer)

Honors and Awards

1994       Fellow, The Geological Society of America
1992       Certificate of Appreciation, American Geological Institute
1989       Certificate of Appreciation, Association of Engineering Geologists
1974-82    Fellow, Geological Society of Canada

Courses Taught (Five Years)

Geol 101  Principles of Geology (6 times)
Geol 312  Structure and Tectonics (4 times)
Geol 612  Applied Structural Geology (4 times)
Geop 681  Seminar (5 times, “Geometry of Thrust Faults” or “Geometry of Normal Faults”)

Students and Postdocs Advised (Five Years)

2005-2007  T. D. (“T.J.”) Waller, II  MS Student  Hess Corporation (Houston)

Five Recent Publications

Five Influential Publications


Spang, John H., and Dorobek, S.L. (1998) Using antithetic normal faults to accurately map growth axial surfaces, Trans. Gulf Coast Assoc. Geologists, 48, 423-429. Many publications directed at a petroleum audience that do not make the citation index, but they are widely used in the industry

Research Publications 23 refereed journal articles, 24 refereed papers in Memoirs and conference proceedings, 104 presentations at national and international conferences. 482 total citations

Selected Projects with Extramural Funding (Five Years)

I have funded my research out of consulting income over the summers. My only graduate student during this reporting period was employed (100%) by Hess Corporation for an entire summer solely to collect data for his thesis. During this employment, he was given unlimited access to proprietary company data in his thesis.

Service and Professional Activities (Selected, Five Years)

<table>
<thead>
<tr>
<th>Year(s)</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002-2006</td>
<td>Advisory Committee for the Vice-President of Student Affairs</td>
</tr>
<tr>
<td>2002-2004</td>
<td>University Distinguished Lectures Committee</td>
</tr>
<tr>
<td>2005-present</td>
<td>American Geological Institute, Workforce Committee</td>
</tr>
<tr>
<td>2006-2007</td>
<td>Interim Head, Department of Geology and Geophysics</td>
</tr>
<tr>
<td>2006-2007</td>
<td>Member, Executive Committee of the College of Geosciences</td>
</tr>
<tr>
<td>2004-2006</td>
<td>Chair, G&amp;G Seminar Committee</td>
</tr>
<tr>
<td>2004</td>
<td>Consultant, Marathon Oil and Gas, Houston</td>
</tr>
<tr>
<td>2007-present</td>
<td>Consultant, Marubini Oil &amp; Gas U.S.</td>
</tr>
</tbody>
</table>
CURRICULUM VITAE

David W. Sparks, Associate Professor

Ph.D., (Geology), Brown University, 1992
B.S. (Geology), Rensselaer Polytechnic Institute, 1985

Professional Experience

2003-present  Associate Professor of Geology and Geophysics, Texas A&M University
1998-2003  Assistant Professor of Geophysics and Geophysics, Texas A&M University
1995-1998  Associate Research Scientist, Lamont-Doherty Earth Observaroty of Columbia University
1992-1994  Postdoctoral Fellow, Lamont-Doherty Earth Observatory of Columbia University
1992  Postdoctoral Research Associate, Brown University
1991-1992  Graduate Research Associate, Division of Earth and Environmental Science, Los Alamos National Laboratory

Honors and Awards

2000  Montague Scholar, Center for Teaching Excellence, Texas A&M University
1992  Director’s Postdoctoral Fellowship, Lamont-Doherty Earth Observatory of Columbia University

Courses Taught (Five Years)

UPAS 181  Life on Mars (Freshman Seminar) (with Dr. M. Tice)
GEOL 101  Principles of Geology
GEOL 310  Planetary Geology
GEOP 341  Global Geophysics
GEOP 470  Computational Methods in Geology and Geophysics
GEOL 485  Geologic Visualization (independent study) (with Dr. B. Herbert)
GEOL 485  Thermal modeling of asteroids (independent study)
GEOP 660  Physics of the Earth’s Interior (with Dr. F. Chester, Dr. A. Kronenberg)
GEOL 664  Mechanical Analysis in Geology (with Dr. D. Wiltschko)
GEOL 689  Earth Science Modeling (with Dr. T. Olszewski)

Students Advised (Five Years)

2008-present  Ahmed Mohammed  PhD Student  Texas A&M University
2007-present  Liran Goren  PhD Student  Weizmann Institute of Science
2007-present  Nataliya Makedonska  PhD Student  Weizmann Institute of Science

Five Recent Publications


**Five Influential Publications**


**Research Publications** 18 refereed journal articles, 33 presentations at national and international conferences or workshops. 455 total citations

**Selected Projects with Extramural Funding (Five Years)**

Incorporated Research Institutions for Seismology, *Technology assistance with implementation and operation of Transportable Array element of USArray and Earthscope*, 2008, $31,000.

Texas Higher Education Coordinating Board, *Advanced Research Program, Is the water table a material free surface?*, 2008-2010, $120,000, Co-I. Dr. H. Zhan.

**Service and Professional Activities (Selected, Five Years)**

2006-present Chair, Department Curriculum Committee
2007-2009 Graduate Fellowship Award Coordinator
CURRICULUM VITAE
Yuefeng Sun, Associate Professor

Ph.D., M.S. (Applied Geophysics), Columbia University, 1994, 1989
B.S. (Applied Geophysics and Geology), China University of Petroleum, 1981

Professional Experience
2007-present Associate Professor, Texas A&M University
Director, TAMU Reservoir Geophysics Program (RGP)
2001-present Adjunct Associate Professor, University of Miami
2005-2006 Associate Professor of Geophysics, The Petroleum Institute, Abu Dhabi, U.A.E.
1998-2005 Doherty Associate Research Scientist, Columbia University, Lamont-Doherty Earth Observatory
1996-2005 Staff Logging Scientist for the international Ocean Drilling Program, Columbia University, Lamont-Doherty Earth Observatory
1995-1997 Postdoctoral Fellow, Columbia University, Lamont-Doherty Earth Observatory
1982-1987 Geophysicist, PetroChina, Xinjiang, China

Honors and Awards
2003-present Sun Model: theoretical rock physics work implemented by Shell Oil company in its advanced carbonate reservoir characterization technology, referred to as the Sun Model by Shell and other major energy companies.
1993 Society of Professional Well Log Analysts Research Award
1990 Campbell Foundation Graduate Fellow
1989 New York State Mining and Mineral Resources Graduate Fellow
1987 Ministry Fellowship Award, Ministry of Petroleum, China

Courses Taught (Three Years)
Geol 404 Geology of Petroleum
Geol 619 Petroleum Geology
Geop 661 Reservoir Rock Physics

Students Advised (Three Years)
2007-present Badr Jan M.S. Student Texas A&M
Qifeng Dou Ph.D. Student Texas A&M
Qian Song Ph.D. Student Texas A&M
Hamid Adesokan Ph.D. Student Texas A&M
Thomas Hull M.S. Student Texas A&M
Elnara Mommadova M.S. Student Texas A&M
Tingting Zhang Ph.D. Student Texas A&M
Rui Cai M.S. Student Texas A&M
Mike Casey M.S. Student Texas A&M
Zhao Zhang M.S. Student Texas A&M
Jindang Cai Ph.D. Student Texas A&M
Satyan Singh Ph.D. Student Texas A&M
Three Recent Publications


Three Influential Publications with Proven Industrial and Societal Impacts


Kuo, J.T., and Y.F. Sun (1993) Modeling gravity variations caused by dilatancies, *Tectonophysics*, 227, 127-143. (Original paper leading to the long-term earthquake prediction and monitoring program by the Chinese Academy of Sciences)

Research Publications 32 refereed journal papers or chapters in books, more than 20 articles and conference proceedings publications, more than 30 presentations at national and international conferences.

Selected Projects with Extramural Funding (Three Years)

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Description</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-2010</td>
<td>Multi-Component Seismic Analysis for Reservoir Description Research Project</td>
<td>$394k</td>
</tr>
<tr>
<td>2007-2010</td>
<td>TAMU Reservoir Geophysics Program</td>
<td>$381k</td>
</tr>
<tr>
<td>2008-2009</td>
<td>EPT log analysis for high-resolution estimation of gas hydrate amount in the Mt. Elbert-01 Stratigraphic Test Well</td>
<td>$22k</td>
</tr>
</tbody>
</table>

Service and Professional Activities (Selected, Five Years)

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-present</td>
<td>Board of Editors, Journal of Computational Acoustics (JCA)</td>
</tr>
<tr>
<td>2000-present</td>
<td>Reviewer of National Science Foundation (NSF) and DOE grants and others</td>
</tr>
<tr>
<td>1998-present</td>
<td>Reviewer of Geophysics, Geophysical Research Letters and others</td>
</tr>
<tr>
<td>1996-present</td>
<td>Session chairpersons of the International Conference on Theoretical and Computational Acoustics and the Chinese Society of Exploration Geophysicists</td>
</tr>
<tr>
<td>2009</td>
<td>Faculty Advisor for the TAMU AAPG Imperial Barrel Award (IBA): First Award - Gulf Regional Competition; Fourth Award - International Competition.</td>
</tr>
<tr>
<td>2008-present</td>
<td>Faculty Advisor for the TAMU AAPG Student Chapter</td>
</tr>
<tr>
<td>2007-present</td>
<td>Member, University Committee on Study Abroad Fellowship (SAF)</td>
</tr>
<tr>
<td>2007-present</td>
<td>Member, G&amp;G Search Committees and other departmental committees</td>
</tr>
</tbody>
</table>
CURRICULUM VITAE

Michael Tice, Assistant Professor

Ph.D., M.S. (Geology), Stanford University, 2006
M.S. (Geology), Duke University, 1999
B.S. (Engineering and Applied Science), Caltech, 1997

Professional Experience

2007-present Assistant Professor, Texas A&M University
2005-2007 Postdoctoral Fellow, Caltech

Courses Taught (Three Years)

Geol 101 Principles of Geology
Geol 306 Intro. to Sedimentology and Stratigraphy
Geol 689 Special Topics in Geobiological Research Methods
Geol 689 Special Topics in the Geobiology of Microorganisms
Geol 681 Seminar in the Evolution of Photosynthesis
Geol 681 Seminar in Geobiology
UPAS 181 Life on Mars

Students Advised (Three Years)

2008-present Kannipa Motanated MS Student Texas A&M
2009-present Rosemary Neyin MS Student Texas A&M
2009-present Amanda Palomo MS Student Texas A&M
2009-present Jian Gong PhD Student Texas A&M

Five Recent Publications


Five Influential Publications


Tice, M.M., B.C. Bostick and D.R. Lowe (2004) Thermal history of the 3.5-3.2 Ga Onverwacht and Fig Tree Groups, Barberton greenstone belt, South Africa, inferred by Raman microspectroscopy of carbonaceous material, Geology, 32, 37-40. 16 Citations (Nov 2009)

Research Publications 10 refereed journal articles, 3 articles and conference proceedings publications, 12 presentations at national and international conferences. 184 total citations

Selected Projects with Extramural Funding (Three Years)


Peering into the Cradle of Life: Scientific Drilling in the Barberton Greenstone Belt, South Africa, ICDP, $400,000, PIs: Nicholas Arndt (Université J. Fourier, France), Alan Wilson (University of Witswatersrand, South Africa), Axel Hofmann (University of Kwazulu-Natal, South Africa), Gary Byerly (Louisiana State University). (participating as drilling team leader)

Service and Professional Activities (Selected, Three Years)
2009-present        Editorial Advisory Board Member, Geobiology
CURRICULUM VITAE
Bridget Wade, Assistant Professor

Ph.D. (Geology & Geophysics), University of Edinburgh, 2001
M.S. with distinction (Micropaleontology), University College London, 1997
B.S. Hons. (Environmental Science, Biogeoscience), University of Leeds, 1996

Professional Experience
2007-present  Assistant Professor, Dept. Geology & Geophysics, Texas A&M University
2005-2007    Research Scientist and Lindemann Fellow, Rutgers University.
2004-2004    NERC Postdoctoral Research Fellow, Cardiff University
2001-2004    NERC Postdoctoral Research Fellow, University of Edinburgh

Honors and Awards
2009        National Science Foundation (NSF) CAREER Award
2008        The Palaeontological Association Hodson Award
2006        The Palaeontological Association Sylvester Bradley Award

Courses Taught (Five Years)
Geol 101    Principles of Geology
Geol 645    Geochronology (with Prof. Miller)
Geol 689    Applied Micropaleontology
Geol 650    Paleoecology (with Prof. Raymond)

Students and Postdocs Advised (Five Years)
2008-present  Shari Hilding-Kronforst  PhD student  Texas A&M
2008-present  Berna Altinsoy  MS student  Texas A&M

Five Recent Publications† = student author
Five Influential Publications


Research Publications 31 refereed journal articles, 3 articles and conference proceedings publications, 27 (first author) presentations at national and international conferences. 206 total citations

Selected Projects with Extramural Funding (Five Years)


2006  The English Speaking Union. *Oligocene tropical sea surface temperatures*. $15,000.

2004  Lindemann Fellowship, English Speaking Union. *The paleobiology of Oligocene planktonic foraminifera*. $30,000 (1/05 – 12/05)

Service and Professional Activities (Selected, Five Years)

2009  Biostratigrapher, Integrated Ocean Drilling Program Expedition 321, Pacific Equatorial Age Transect (May-June)

2009-present  Seismologist Search Committee, Dept. Geology & Geophysics, Texas A&M

2009-present  Ocean Drilling and Sustainable Earth Sciences, Graduate Fellowship Subcommittee, Texas A&M

2008-present  Faculty Advisor to the Geology and Geophysics Graduate Student Council

2008-present  Geology & Geophysics Seminar Committee

2007-present  Editorial Advisory Board Member, Open Journal Paleontology

2007-2009  Graduate Admissions Committee

2005-present  Chair, Paleogene Planktonic Foraminiferal Working Group, part of the International Subcommission on Paleogene Stratigraphy

2005  Sedimentologist, The International Continental Scientific Drilling Program and the USGS. Chesapeake Bay impact crater (September 2005).
CURRICULUM VITAE
Robert Weiss, Assistant Professor

Dr. rer. nat Westphalia-Wilhelms University Muenster, Germany, 2005
Diploma (M.S. equivalent), Vordiplom (B.S. equivalent) Friedrich-Schiller
University, Jena, Germany, 2002, 1999

Professional Experience
2008-present Assistant Professor of Geology and Geophysics, Texas A&M University
2005-2008 Visiting Scholar, Joint Institute for the Study of the Atmosphere and Ocean,
University of Washington, Seattle
2005 Researcher, Westphalia-Wilhelms University Muenster, Germany

Honors and Awards
2006 Hildegard and Karl-Heinrich Heitfeld Award
2005 Award for Ph.D thesis at Westphalia-Wilhelms University Muenster, Germany
graded with Summa Cum Laude in 2005

Courses Taught (One Year)
Geol 668 Clastic Sedimentology and Sedimentary Petrology
Geol 306 Sedimentology and Stratigraphy
Geop 681 Basin Analysis

Students and Postdocs Advised (Four Years)
2008-present Bradley Weymer MS Student Texas A&M
2009-present Matthew Wehner MS/PhD Student Texas A&M
2006-present Bre MacInnes MS/PhD Student University of Washington
2006-present Maria Martin MS/PhD Student University of Washington

Five Recent Publications
tsunami of 2007 September 12, Bengkulu province, Sumatra, Indonesia: post-tsunami field survey


Bourgeois, J., Weiss, R. (2009) “Chevrons” are not mega-tsunami deposits -- a sedimentologic
assessment, Geology, 37(5), 403-406.

Weiss, R. (2008) Sediment grains moved by passing tsunami waves: Tsunami deposits in deep water,
Marine Geology, 250, 251-257.

Wei, Y, Bernard, E. N., Tang, L., Weiss, R., Titov, V.V., Moore, C., Spillane, M., Hopkins, M. and
Five Influential Publications


Research Publications 12 refereed journal articles, 5 articles and conference proceedings publications, over 40 presentations at national and international conferences. 29 total citations

Selected Projects with Extramural Funding (One Year)

NSF-EAR-0956094, CAREER: Sediments and sediment transport due to tsunamis, pending, $588,227


Service and Professional Activities (One Year)

Fall 2008-present Member of Graduate Admission Committee

Fall 2008-Spring 2009 Member of Sedimentology/Stratigraphy Search Committee
CURRICULUM VITAE
David V. Wiltschko, Professor

Ph.D., M.S. (Geology), Brown University, 1977, 1974
B.A. (Geological Sciences), University of Rochester, 1971

Professional Experience
2002-present: Michel. T. Halbouty Chair in Geology
1994-present: Professor, Department of Geology and Geophysics, Texas A&M University
1989-1994: Director, Center for Tectonophysics, Texas A&M University
1986-1994: Associate Prof., Department of Geology, Texas A&M University
1985-1989: Associate Director, Center for Tectonophysics, Texas A&M University
1984-1986: Assistant Prof., Department of Geology, Texas A&M University; Faculty Associate, Center for Tectonophysics, Texas A&M University
1979-1983: Assistant Prof., Department of Geological Sciences, Univ. of Michigan
1977-1979: Visiting Assistant Prof., Department of Geological Sciences, Univ. of Michigan

Honors and Awards
2002 M. T. Halbouty Chair, Geology
2000 College of Geosciences, Distinguished Achievement Award, Faculty Research
1988 Association of Former Students, Texas A&M University, Distinguished Teaching Award

Courses Taught (Five Years)
Geol 312 Structural Geology
Geol 352 GPS in the Geosciences
Geol 612 Applied Structural Geology
Geol 629 Regional Geology of North America (Tectonics)
Geol 658 Earth Systems through Deep Time
Geol 664 Mechanical Analysis in Geology

Students and Postdocs Advised (Five Years)
2007-2008 John Panian Postdoctoral Fellow Independent consultant
2002-2006 Lauren Hassler MS Student Attorney
1999-2007 Pablo Cervantes PhD Student BP
1999-2004 Jae-Won Chung MS Student Univ of Missouri, PhD student
2002-2009 Tosin Majekodunmi MS Student BP
2002-2008 Fernando Roa-Rodriguez MS Student Conoco/Phillips
2002-2005 Vernon Moore MS Student Marathon
2007- Harold Johnson MS Student
2008- Shay Chapman MS Student
2008- Jennifer Piper MS Student ExxonMobil
2008- Sean Steen MS Student

Five Recent Publications


**Five Influential Publications**


**Research Publications** 59 refereed journal articles, 86 presentations at national and international conferences. 713 total citations

**Selected Projects with Extramural Funding (Five Years)**

NSF, *The Thermo-kinematic evolution of the Taiwan mountain belt*: $139,475, 1/00-12/05.


**Service and Professional Activities (Selected, Five Years)**

1998-2000, 2005  
NSF Tectonics panels

1996-present  
Co-founder and webmaster, Appalachian Tectonics Study Group

2008-2009  
Associate Editor, Journal of Structural Geology

2004-2006  
College of Geosciences Research Committee

2005-2008  
College of Geosciences Advisory Committee (GFAC); Chair 2007-2008.

2008-2009  
University Dean of Geosciences Search Committee

2004-present  
Executive Committee, Geology and Geophysics

2005-2009  
Tenure and Promotion Committee, Geology and Geophysics (Chair 2006)

2008-present  
Petroleum Geology Working Group (Committee)

2004-present  
Chair, Professorships and Chairs Committee, Geology and Geophysics

2004-present  
5 faculty search committees

2005-2007  
Graduate Committee
CURRICULUM VITAE

Thomas E Yancey, Professor

Ph.D. (Paleontology), UC Berkeley, 1971
M.A., B.A. (Geology), UC Berkeley, 1968, 1966

Professional Experience

1994–present  Professor of Geology and Geophysics, Texas A&M University
1984–1994  Associate Professor of Geophysics, Texas A&M University
1980–1984  Assistant Professor of Geology, Texas A&M University
1975–1980  Assistant Professor of Geology, Idaho State University
1971–1975  Lecturer, University of Malaya

Honors and Awards

1984  TAMU Geosciences Distinguished Teaching Award

Courses Taught (Five Years)

GEOL 101  Principles of Geology
GEOL 106  Historical Geology
GEOL 685-625  Geochronology

Students and Postdocs Advised (Five Years)

2007–present  Regina Dickey  Ph.D. student  Texas A&M

Five Recent Publications


Five Influential Publications


Research Publications 61 refereed journal articles, 6 articles and conference proceedings publications, 96 presentations at national and international conferences. 476 total citations

Selected Projects with Extramural Funding (Five Years)


Service and Professional Activities (Selected, Five Years)

2007-present Member, Executive Committee of the College of Geosciences
2005-present Member, Curriculum Committee
2004-2007 Member, TAMU Faculty Development Leave Committee
CURRICULUM VITAE
Hongbin Zhan, Fish Professor

Ph.D. (Hydrology/Hydrogeology), University of Nevada, Reno, 1996
M.S. (Physics), University of Nevada, Reno, 1993
B.S. (Physics), University of Science and Technology of China, 1989

Professional Experience
2009 Ray C. Fish Professor in Geology
2007-present Professor of Geology and Geophysics, and Professor of Water Management and Hydrological Sciences, Texas A&M University (TAMU)
2002-2007 Associate Professor of Geology and Geophysics, TAMU
2005-2007 Associate Professor of Water Management and Hydrological Sciences, TAMU
1996-2002 Assistant Professor of Geology and Geophysics, TAMU
1995-1996 George B. Maxey Fellow, Desert Research Institute (Nevada)

Honors and Awards
2009 Dean’s Distinguished Teaching Award, College of Geosciences, TAMU.
2006 GSA Fellow
2004 Distinguished Oversea Scientist Award, National Science Foundation of China
2002 Fred Burggraf Award, Transportation Research Board, The National Academies
1999 Center for Teaching Excellent Montague Scholar, TAMU

Courses Taught (Five Years)
Geol 410 Hydrogeology
Geol 625 Applied Ground Water Modeling
Geol 621 Contaminant Hydrogeology
Geol 685 Hydrogeophysics: Past, Present, and Future

Graduate Students Advised (Five Years)
Former Students: Eungyu Park (PhD, 2002), Mazda Kompani-Zare (PhD, 2003), Dongmin Sun (PhD, 2005), Aiguo Bian (PhD, 2006), Trin Intaraprason (PhD, 2007), Oke Nwaneshiu (PhD, 2007), Guangyao Gao (PhD, 2009), Zhang Wen (PhD, 2009), William Dugat (MS, 2009), Kent Langerlan (MS, 2009).

Present Students: Zhou Chen (PhD), Jian Li (PhD), Sungwon Kim (PhD), Ahmed Mohamed (PhD), Kehua You (PhD), Xu Xu (PhD), Sireesh Dadi (MS), Sevgi Cavdar (MS), Tiffany DeLeon-Early (MS), John Mieles (MS)

Five Recent Publications

**Five Influential Publications**


**Research Publications**: 66 refereed publications (53 in international journals, 9 in Chinese journals, and 4 in book chapters and reports), 75 presentations at national and international conferences. 278 total citations

**Selected Projects with Extramural Funding (Five Years)**


**Service and Professional Activities (Selected, Five Years)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-present</td>
<td>Associate Editor, Journal of Hydrology</td>
</tr>
<tr>
<td>2003-2005</td>
<td>Associate Editor, Water Resources Research</td>
</tr>
<tr>
<td>2000-present</td>
<td>Associate Editor, Journal of Contaminant Hydrology</td>
</tr>
<tr>
<td>2005-present</td>
<td>Guest Professor, China Agricultural University</td>
</tr>
<tr>
<td>2006-present</td>
<td>Guest Professor, Huazhong University of Science and Technology</td>
</tr>
<tr>
<td>2004-2007</td>
<td>Guest Professor, Graduate School of Chinese Academy of Sciences</td>
</tr>
<tr>
<td>2005-2006</td>
<td>Chair of Horton Research Grant Committee, AGU</td>
</tr>
<tr>
<td>2004</td>
<td>Member of Horton Research Grant Committee, AGU</td>
</tr>
<tr>
<td>2008</td>
<td>Panelist, DOD/EPA/DOE “Strategic Environmental Research and Development Program (SERDP)</td>
</tr>
<tr>
<td>2008-present</td>
<td>Evaluate Tenure and Promotion packages for University of Nevada, Reno, University of Utah, Colorado School of Mines, and Wayne State University.</td>
</tr>
<tr>
<td>2007-present</td>
<td>Member, Department Tenure and Promotion Committee</td>
</tr>
<tr>
<td>2000-present</td>
<td>Member, Department Graduate Admission Committee</td>
</tr>
<tr>
<td>2007-present</td>
<td>Member, Department Space Committee</td>
</tr>
<tr>
<td>2006</td>
<td>Chair, Department Hydrogeology Search Committee</td>
</tr>
<tr>
<td>1998-present</td>
<td>Department Undergraduate Advisor</td>
</tr>
</tbody>
</table>
A.2. Joint Faculty
CURRICULUM VITAE
Blasingame, Joint Professor,
Geology and Geophysics, and Petroleum Engineering

PhD, MS, BS Petroleum Engineering, Texas A&M University, 1989, 1986, 1984

Professional Experience
2005-present Professor of Petroleum Engineering, Texas A&M University
1996-2005 Associate Professor of Petroleum Engineering, Texas A&M University
1991-1996 Assistant Professor of Petroleum Engineering, Texas A&M University
1989-1990 Research Associate of Petroleum Engineering, Texas A&M University

Honors and Awards
2005 Robert L. Whiting Endowed Professorship, Texas A&M University
1994 Tenneco Meritorious Teaching Award
1986 TAMU Association of Former Students Teaching Award

Courses Taught (Five Years)
PETE 309 Rock Properties
PETE 311 Reservoir Petrophysics
PETE 324 Well Performance
PETE 412 Well Testing
PETE 613 Natural Gas Engineering
PETE 620 Fluid Flow in Petroleum Reservoirs
PETE 663 Formation Evaluation/Analysis of Reservoir Performance

Students and Postdocs Advised (Five Years)
2009 Maria Nass MS Student BP
2009 Tony Kelly MS Student Kinder Morgan
2009 Roland Froboese MS Student DeGolyer/MacNaughton
2008 Faig Hasanov MS Student BP (Azerbaijan)
2007 Shahram Amini PhD Student Schlumberger
2007 Eser Akoz MS Student Schlumberger
2006 David Craig PhD Student Reservoir Development Corp
2005 Jamal MS Student Total

Five Recent Publications

### Five Influential Publications


### Research Publications

12 refereed journal articles, 91 articles and conference proceedings publications, 41 presentations at national and international conferences.

### Selected Projects with Extramural Funding (Five Years)

- **RPSEA, Coupled Flow-Geo-Mechanical-Geophysical-Geochemical (F3G) Analysis of Tight Gas Production**, 2009-2011, $2,900,000, Co-PIs Dr. T.A. Blasingame, Dr. G. Moridis (Lawrence Berkeley)
- **RPSEA, A Self-Teaching Expert System for the Analysis, Design, and Prediction of Gas Production from Shales**, 2008-2010, $1,774,840, Co-PIs Dr. T.A. Blasingame, Dr. G. Moridis (Lawrence Berkeley)
- **Apache Corporation, Klinkenberg-Correction for Low Permeability Sandstones**, 2006, $10,000, PI Dr. T.A. Blasingame.
- **Anadarko Petroleum Corp, Semi-Analytical Estimation of Permeability Obtained from Capillary Pressure**, 2004, $20,000, PI Dr. T.A. Blasingame.

### Service and Professional Activities (Selected, Five Years)

- **2008** SPE Advanced Technology Workshop on Continuous Reservoir Monitoring, Co-Chair
- **2008** SPE Advanced Technology Workshop on Unconventional Gas Reservoirs
- **2008** SPE Advanced Technology Workshop on Reservoir Char. and Performance Simulation
- **2007** SPE Unconventional Gas Reservoirs Steering Committee
- **2007** SPE Advanced Technology Workshop on Diagnostics for Fractured and Horizontal Wells
- **2007** SPE Advanced Technology Workshop on Analysis of Reservoir Performance, Co-Chair
- **2006** SPE Advanced Technology Workshop on High Gross Production Fields, Co-Chair
- **2006** SPE Advanced Technology Workshop on Opportunities in Mature Oil Fields, Co-Chair
- **2006** SPE Advanced Technology Workshop on Technologies to Create More Value from Mature Fields, Co-Chair
- **2005-present** SPE RDD Advisory Committee
CURRICULUM VITAE
Mary Jo Richardson, Joint Professor, Oceanography and Geology and Geophysics

A.B. Smith College, June (Geology/Mathematics) 1975
Ph.D. (Joint Program in Oceanography) Massachusetts Institute of Technology/Woods Hole Oceanographic Institution- 1980

Professional Experience
2009
Hellenic Centre for Marine Research, Athens, Greece

2006-present
Texas A & M University, Depts. of Oceanography and Geology/Geophysics Regents’ Professor

1994-2006
Texas A & M University, Depts. of Oceanography and Geology/Geophysics Professor

2002–2004
Texas A&M University, College of Geosciences, Interim Dean

1993-2002
Texas A & M University, College of Geosciences Associate Dean for Academic Affairs

1996
NOAA/Pacific Marine Environmental Lab

1990-1994
Texas A & M University, Departments of Oceanography and Geology Associate Professor

1986-1990
Texas A & M University, Department of Geology Visiting Assistant Professor

1985-1986
Texas A & M University, Department of Oceanography Research Associate

1981-1985
City University of New York (Lehman), Dept.of Geol. and Geog. Assistant Professor

1981
State University of New York (Purchase), Dept. of Natural Science Physical Geology Professor, Summer Session

1980-1981
Lamont-Doherty Geological Observatory, Palisades, New York Research Scientist

Honors and Awards
2007
Women’s Faculty Network Mentoring Award — 1st recipient (University-wide)

1991 -1996
Texas A&M University, International Excellence Award –National Science Foundation Faculty Award for Women Scientists and Engineers.

1991
Texas A&M University, Association of Former Students Distinguished Teaching Award (College Level)

1991
Sigma Xi

1975
Phi Beta Kappa

Five Recent Publications


Five Influential Publications


Research Publications 26 refereed journal articles, 624 total citations

Service and Professional Activities (Selected, Five Years)

2006 - 2009 NSF Advisory Council for the Geosciences Directorate,

2007 - present NSF Education and Outreach Subcommittee (chair)

2006 NSF Committee of Visitors (COV) for Ocean Sciences Division, co-chair,

2003 – 2005 Consortium for Ocean Research and Education (CORE): Executive Committee

2007 - present National Association of State Universities and Land Grant Colleges (NASULGC)/ Association of Public and Land-grant Universities(APLU) Board of Oceans and Atmosphere - Executive Committee – elected,

2003 - present Phi Beta Kappa, Committee on Qualifications

2005 – present University Corporation for Atmospheric Research (UCAR) Scientific Program and Evaluation Committee,

1999 – 2006 University Corporation for Atmospheric Research (UCAR), Board of Trustees

2007 – 2009 State of Texas, State Board of Education Earth and Space Science committee
CURRICULUM VITAE
William W. Sager, Joint Professor, Oceanography and Geology and Geophysics

Ph.D., M.S. (Geology & Geophysics), University of Hawaii, 1983, 1979
B.S. (Physics), Duke University, 1976

Professional Experience
1995-present  Professor of Oceanography, Texas A&M University
1989-1995  Associate Professor of Oceanography, Texas A&M University
1983-1989  Assistant Professor of Oceanography, Texas A&M University
1983-present  Joint appointment with Geology & Geophysics, Texas A&M University

Honors and Awards
2009  Association of Former Students Distinguished Research Award
2003-present  Jane and R. Ken Williams ’45 Chair in Ocean Drilling Science, Technology, and Education
2003  TAMU Geosciences Distinguished Research Award

Courses Taught (Five Years)
OCNG 205  Introduction to Oceanography
GEOP 666  Geodynamics
OCNG 681  Seminar: How to Write and Publish a Scientific Paper
OCNG 630  Geological Oceanography

Students and Postdocs Advised (Five Years)
Ph.D. advisory committee chair: Paul, Christopher (OCNG, present); Tominaga, Masako (OCNG, 2009); Erck, Steven (GEPL, 2004);
M.S. advisory committee chair: Eisin, Amy (OCNG, 2009); Beaman, Mellissa (OCNG, 2006); Maddox, Donald (GEPL, 2005); Tominaga, Masako (OCNG, 2005); Patch, Mary (OCNG, 2005); De la Torre, Giorgio (OCNG, 2005)

Five Recent Publications (*student author)
Five Influential Publications (*student author)

Research Publications 94 refereed journal articles; 103 presentations at national and international conferences, 899 citations.

Selected Projects with Extramural Funding (Five Years)
Texas General Land Office, Oyster Reef and Anthropogenic Impacts Mapping Project in Central Texas Estuaries, Coastal Impacts Assistance Program, Texas General Land Office, 6/1/02-9/30/05, $222,410, co-PIs William W. Sager, T. Dellapenna (TAMUG).

Service and Professional Activities (Selected, Five Years)
2009-present Member, IODP Science Advisory Structure, Site Survey Panel
2009 Co-chief Scientist: IODP Expedition 324
2006-present Administrative Law Judge, Technical, US Nuclear Regulatory Commission
2005-2007 Member, US Science Advisory Committee for Scientific Ocean Drilling
2001-2003 Member, JOIDES Science Committee
2003-present Member College of Geosciences ODASES Committee
2008-present Member Oceanography Recruiting and Academic Advisory Committee
2006-2007 Member Oceanography Department Advisory and Budget Committee
2006-2007 Member, Oceanography marine geologist faculty search committee
2005-2006 Chair, Oceanography paleoceanographer faculty search committee
2003-2008 Chair, Oceanography ship acquisition committee
Vatche P. Tchakerian, Joint Professor
Geography and Geology and Geophysics

Ph.D., Geography (Geomorphology), UCLA, 1989

Professional Experience:
2004-2008      Associate Dean of Academics, College of Geosciences, TAMU
2002-2004      Acting Associate Dean of Academics, College of Geosciences, TAMU
2002-present   Professor, Depts of Geography and Geology & Geophysics, TAMU
1996-1997      Interim Department Head, Department of Geography, TAMU
1995-2002      Associate Professor, Department of Geography, TAMU
1989-1995      Assistant Professor, Department of Geography, TAMU

Courses Taught
Geog 305     Geography of Texas
Geog 321     Geography of Africa
Geog 331     Geomorphology
Geog 400     Arid Lands Geomorphology
Geog 450     Field Geography
Geos 410     Global Change
Geog 666     Coastal Geomorphology
Geog 696     Remote Sensing in Geomorphology

Graduate Students
Chair and Co-Chair: 4 Ph.D. and 18 M.S. (1995 to 2009)

Five Recent Publications


Five Influential Publications


Selected Projects with Extramural Funding (Five Years)

CURRICULUM VITAE
Deborah J. Thomas, Joint Assistant Professor, Oceanography and Geology and Geophysics

B.S., Brown University, 1995

Professional Experience

2004 - present  Assistant Professor, Texas A&M University,
2002 – 2004  Post-doctoral Researcher, University of North Carolina

Honors and Awards

2008-2009  Distinguished Lecturer, Consortium for Ocean Leadership
2008  Montague Center for Teaching Excellence Award, Texas A&M
2007  Distinguished Achievement Teaching Award (College Level), Texas A&M Association of Former Students

Courses Taught (Five Years)

Geol 101  Principles of Geology
Geos 410  Global Change
Ocng 251  Oceanography
Ocng 430  Geological Oceanography
Ocng 674  Paleoceanography

Students and Postdocs Advised (Five Years)

Rachael Via  MS Student  2006  ExxonMobil
Chioma Okafor  PhD Student  2009  Chevron

Five Recent Publications


Five Influential Publications


Research Publications 16 refereed journal articles, 22 presentations at national and international conferences. 88 citations

Selected Projects with Extramural Funding (Five Years)


NSF, *Did Deep Waters Form at High Latitudes During the Middle to Late Cretaceous Greenhouse?*, September 2006 – August 2009, $155,585.


Service and Professional Activities (Selected, Five Years)

2008 Co-convened session at Fall AGU meeting
2007 to present Instructor for Deep Earth Academy teacher training programs since
2009 Panel member, NSF OCE Committee of Visitors
2005 Panel member, NSF OCE Marine Geology and Geophysics program
2005 Invited participant to the NSF Proxies workshop, December 10-22
2004 Invited participant to the NSF Geosystems workshop, September 9-11
2004 Invited participant in the CHRONOS Geochemical Cycles workshop June 25-26,
2003 ODP Leg 208 Shipboard Scientist (inorganic geochemist) March 9- May 8
2001 ODP Leg 198 Shipboard Scientist (sedimentologist) August 29- October 24
A.3. Adjunct Faculty
CURRICULUM VITAE
Walter B. Ayers, Jr., Adjunct Professor

Ph.D. (Geology), The University of Texas at Austin, 1984
B.S., M.S. (Geology), West Virginia University, 1969, 1971

Professional Experience
2001-present Texas A&M University Visiting Professor, Dept. of Petroleum Engineering, and Adjunct Professor, Dept. of Geol. and Geophysics
1995-1997 Vice President, Geosciences
1993-1995 Taurus Exploration, Inc. (now, Energen Resources) Manager of Geology, General Manager of Geology
1991-1993 Energen Resources, Senior Exploration Geologist, Senior Technical Manager
1989-1991 The University of Texas at Austin, Bureau of Economic Geology, Research Scientist; Program Manager, Natural Gas and Coal Research
1979-1989 The University of Texas at Austin, Bureau of Economic Geology Research Assistant, Research Associate, Research Scientist Associate
1972-1978 Tidewater Community College Instructor to Assistant Professor
1971-1972 Winthrop University Instructor
1960-1965 U.S. Air Force, 820 Strategic Air Command Medical Radiologic Technologist (RT, ARRT)

Honors and Awards
2008 Distinguished Service Award, AAPG, Energy Minerals Division
2003 Certificate of Merit, American Association of Petroleum Geologists, EMD
2000 Excellence in Presentation Award, AAPG, EMD
1995 Distinguished Alumni Professional Achievement Award, West Virginia Univ.
1991 Best Paper Award, AAPG, EMD
1984 Best Paper Award, AAPG, EMD

Courses Taught (Five Years)
Geol 404 Geology of Petroleum
PETE 321 Formation Evaluation
PETE/Geol 400/685 Reservoir Description
PETE 612 Unconventional Oil and Gas Reservoirs
PETE 663 Formation Evaluation and Analysis of Reservoir Performance
PETE 689 Special Topics in CO\textsubscript{2} Capture and Uses: Sequestration, Enhanced Oil Recovery (EOR)

Students and Postdocs Advised or Co-Advised (Five Years)
2002-2009 Five Master of Eng. Students MENG
2007-present Yao Tian MS Schlumberger
2008-2009 Ting He MS Schlumberger
2005-2007 Jianwei Wang PhD Schlumberger DCS
2006-2007 Sunil Ramaswamy MS Schlumberger
2005-2006 Yamin Li MS Schlumberger
2002-2006 Rahila Ramazanova, PhD British Petroleum

Five Recent Publications


Five Influential Publications


Selected Projects with Extramural Funding (Five Years)

Crisman Center for Unconventional Resources and NEXEN, Controls on Barnett Shale Gas Production Rates, 2007-2009, $75,000.

Crisman Center for Reservoir Description and Newfield Exploration, Infill Drilling Potential of Green River Fm, Monument Butte Oil Field, Utah, 2005-2008, $180,000, Co-PIs Dr. D.A. McVay and Dr. J.L. Jensen.


U.S. Department of Energy, NETL with Anadarko, CO2 Sequestration Potential of Texas Low-Rank Coals, 2002-2006, $450,000, Co-PIs Dr. D.A. McVay and Dr. J.L. Jensen.

Service and Professional Activities (Selected, Five Years)

2008– present Member AAPG North American Distinguished Lecture Committee


2006 – 2007 Member, Board of Advisors, WellDog oilfield services company, Laramie, WY.


2004-2009 Instructor, 13 industry short courses
CURRICULUM VITAE
Arnold H. Bouma, Adjunct Professor

Ph.D., M.S. (Sedimentary Geology), State Univ., Utrecht, 1961, 1959
B.S. (Geology), State University, Groningen, The Netherlands

Professional Experience

2006-present  Director of the Center for Shale Studies, TAMU
2005-present  Adjunct Professor, Department of Geology and Geophysics, TAMU
1990 - 1992  Head, School of Geosciences, Louisiana State University
1988 - 2005  McCord Professor in Sedimentary Geology, Louisiana State University
1970 - 1975  Professor, Geological Oceanography, Texas A&M University
1966 - 1970  Associate Professor, Geological Oceanography, Texas A&M University
1963 – 1966  Instructor, Geological Institute, Utrecht, The Netherlands
1962 - 1963  Fulbright Post-doctoral fellowship, Scripps Institution of Oceanography

Honors and Awards

2007  Sidney Powers Memorial Award, AAPG
2007  Honorary Member AAPG
2007  Honorary Member SEPM
2006  Geo-Legend. Houston Geological Society
1971-2000  25 additional awards

Courses Taught (Five Years)

Geol 306  Sedimentology and Stratigraphy
Geol 668  Clastic Sedimentology and Sedimentary Petrology
Geol 681  Seminar on Shales

Students Advised

Texas A&M University  13 MS Students
  7 PhD Students
Louisiana State University  29 MS Students
  5 PhD Students
Univ. Port Elizabeth, S. Africa  1 PhD Student

Five Recent Publications

Bouma, A.H., A.M. Delery, and A. Benavides-Iglesias (2006) Basin characteristics, tectonic history, and grain size are main influence in the transport and deposition of turbidity currents, Gulf Coast Assoc. Geol. Soc. and Gulf Coast Section SEPM Trans., 56, 103-118.
Bouma, A.H., and E.D. Scott (2005) Source-to-sinks: the importance of the updip coastal area in defining deep-water sand characteristics, Gulf Coast Assoc. Geol. Soc. and Gulf Coast Section SEPM Trans., 55, CD.


Five Influential Publications


Bouma, A.H. and J.R. Curry (1964) Editorial, Marine Geology, 1, 1-3


Research Publications 4 books, 8 books edited, 133 refereed journal articles, 76 articles and conference proceedings publications, 53 technical reports, 32 book reviews, and 68 presentations at national and international conferences, 417 citations, significant, uncited impact on deep-water stratigraphy and petroleum and gas exploration

Service and Professional Activities (Selected)

2000-2001 President, Society for Sedimentary Geology (SEPM)
1989-1990 Director, Basin Research Institute, LSU
1987-1989 Executive Committee, Councilor for Sedimentology, Society of Economic Paleontologists and Mineralogists
1985 Acting Vice President, GR&DC Exploration Research, Houston, TX
1983-1985 Chief Scientist, Lithostratigraphy, GR&DC Exploration & Research, Houston TX
1983-1984 Tectonics Panel, Advanced Ocean Drilling Project
1981-1982 Distinguished Lecturer, AAPG Continuing Education
1980-2000 Editor, Geo-Marine Letters
1979-1983 Passive Ocean Margin Panel, JOIDES
1973-1977 Vice Chairman, Marine Committee of the AAPG
1968-1976 Gulf Panel for JOIDES Drilling Project
1966- Present Editorial Board of Marine Geology
1963-1967 Committee on Publication and Printing International Union of Geol. Sciences
1963-1966 Editor, Marine Geology
1959-1962 Treasurer, International Association of Sedimentologists
CURRICULUM VITAE
Jörg Geldmacher, Adjunct Professor and IODP Staff Scientist

Habilitation, University Kiel, Germany, 2007
Dr. rer. nat. (Geology), University Kiel, Germany, 2000
Diploma (Geology and Paleontology), University Kiel, Germany, 1996

Professional Experience
2008-present Adjunct Professor, Dept. of Geology and Geophysics, Texas A&M University
2007-present Staff Scientist, Integrated Ocean Drilling Program, Texas A&M University
2002-2006 Research Associate, IFM-GEOMAR, Germany
2002-2002 Research Associate, San Diego State University
2000-2002 Postdoctoral Fellow, San Diego State University
1996-1999 Scientific Employee, Geomar Research Center, Kiel, Germany

Courses Taught (Five Years)
Spring 2006 Magmatic processes and plate tectonics (in German, Univ. Kiel)
Winter 2005/6 Introduction into the geochemistry of rocks (in German, Univ. Kiel)
Spring 2005 Magmatic processes and plate tectonics (in German, Univ. Kiel)
Winter 2004/5 Geochemistry of magmatic systems (in German, Univ. Kiel)

Students and Postdocs Advised (Five Years)
N.A.

Five Recent Publications


90

**Five Influential Publications**


**Research Publications** 17 refereed journal articles, 30 presentations at national and international conferences.

**Selected Projects with Extramural Funding (Five Years)**

DFG, (German Research Foundation) U-Th-Pb, Nd and Hf isotopic investigation of a complete in situ section of oceanic crust formed at a superfast spreading ridge, 2006-2008, PI: Dr. K. Hoernle (I was main author of proposal but not PI)

DFG, Age and geochemistry of igneous rocks in the Guatemalan forearc: Implications for the early history of the Caribbean Large Igneous Province, 2004-2006, PI: Dr. K. Hoernle (I was main author of proposal but not PI)

DFG, Origin and impact of volcanism in the eastern North Atlantic and western Mediterranean, 2002-2004 PI: Dr. K. Hoernle, Dr. P. v.d. Bogaard, Dr. A. Kluegel (I was main author of the proposal but not PI)

DFG, Hf isotopic variations in volcanic rocks from the Caribbean Large Igneous Province and Galápagos hotspot tracks, 2000-2002, PI: J. Geldmacher
CURRICULUM VITAE

John Robert Hopper, Associate Adjunct Professor

Ph.D., M.A. (Geophysics), Columbia University, 1994, 1989
B.A. with High Honors (Geology), Colgate University, 1987

Professional Experience

2008-present  
Associate Adjunct Professor of Geology & Geophysics, Texas A&M University
2008-present  
Geol Survey Denmark & Greenland, Copenhagen, Denmark
2005-2008  
Assist Professor of Geology and Geophysics, Texas A&M University
2003-2004  
Research Scientist, GEOMAR Marine Research Center, Christian Albrechts University, Kiel, Germany
1999-2003  
Senior Scientist, Danish Lithosphere Center, Copenhagen, Denmark
1994-1999  
Project Scientist, Danish Lithosphere Center, Copenhagen, Denmark

Honors and Awards

2007-2008  
Distinguished Lecturer, NSF Margins Program
1989  
Sarah Fitzgerald Langer Book Prize, Columbia University
1989  
Bruce Heezen Prize, Columbia University

Courses Taught (Five Years)

Geop 629  
Seismic Interpretation
Geop 660  
Physics of the Earth's Interior
Geop 666  
Geodynamics
Geop 685  
Geophysical Data Analysis
Geop 681  
Seminar on Arctic Geology and Tectonics

Students and Postdocs Advised (Five Years)

Veronica Arrigoni  
MS Student  
Texas A&M
John Armitage  
PhD Student  
NOC, UK
David Dickins  
MS Student  
Texas A&M
Dayton Dove  
MS Student  
Texas A&M
Amy Eisin  
MS Student  
Texas A&M
Janelle Greenidge  
MS Student  
Texas A&M
Idris Murad  
MS Student  
Texas A&M
Luis Navarro  
MS Student  
Texas A&M
Jamie Sanchez  
MS Student  
Texas A&M
Masako Tominaga  
PhD Student  
Texas A&M

Five Recent Publications


Five Influential Publications


Research Publications 22 refereed journal articles, 3 articles and conference proceedings publications, 42 presentations at national and international conferences. 529 total citations

Selected Projects with Extramural Funding (Five Years)


Geophysical Sea Work (Selected)

2005 USCGC Icebreaker Healy: HOTRAX 05, Two ship (with Swedish Icebreaker Odin) expedition for seismic, coring, and physical oceanography across the arctic basin.


Invited and Keynote Lectures (Selected, Five Years)

2007 Rift to Ridge Keynote Lecture, National Oceanography Centre, Southampton UK
2007 University of Oviedo, Oviedo, Spain
2007 California Institute of Technology
2007 Rice University
2006 Louisisana State University
2005 Institute for Geophysics, University of Texas
CURRICULUM VITAE

Jennifer T. McGuire, Associate Adjunct Professor,
University of St. Thomas

Ph.D. (Environ. Geoscience-Toxicology) Michigan State University, 2002
B.S. (Environmental Geoscience) Michigan State University, 1998

Professional Experience

2009-present  Associate Professor. Department of Geology, University of St. Thomas
2009-present  Adjunct Assoc. Professor, Dept Geology and Geophysics, Texas A&M Univ.

Honors and Awards

2007-2008  Montague-Center for Teaching Excellence Scholar
2000  Best Student Presentation, 23rd Annual Midwest Environ. Chemistry Workshop
2000  Neal Endowed Fellowship
2000  Warren W. Wood Fellowship for Student Research in Hydrogeology
1999  Warren W. Wood Fellowship for Student Research in Hydrogeology

Courses Taught (Five Years)

GEOL 101  Principles of Geology
GEOL 646  Biogeochemical Cycling in Subsurface Systems
GEOL 689  (team taught) Geochemical Characterization of Natural Systems
GEOS 105-  (team taught) Introduction to Environmental Geosciences
GEOL 685  Special Topics in Biogeochemical Cycling -
GEOL 681  (with Dr. Raymond) Seminar Course- Wetlands Through Time
GEOL 681  Seminar Course- Low-Temperature Geochemical Modeling Using PHREEQC

Students and Postdocs Advised (Five Years)

2009  Andrea Howson  M.S.  Marathon
2008  Tara Kneeshaw  Ph.D.  Asst. Professor, Cal State Fullerton
2007  Susan Baez-Cazull  Ph.D.  Water Remediation Technology, LLC
2005  Krisha Tracy  M.S.  Haliburton
In Progress  Bhavna Arora (co-chair)  Ph.D.
In Progress  David Hansen  Ph.D.  Conoco Philips, Houston, TX
2007-present  Fabio Sartori  Post-doctoral
2007-present  Itza Mendoza (with M.S. Phanikumar)  Post-doctoral

Five Recent Publications


Five Influential Publications


Research Publications 10 refereed journal articles, 3 articles and conference proceedings publications, 47 presentations at national and international conferences. 105 citations

Selected Projects with Extramural Funding (Five Years)

NSF-Hydrological Sciences-Flow-Induced Redox Geochemistry within Fractured/Macroporous and Layered Vadose zone 05/07 $480,000, Co-PI with Binayak Mohanty

NSF-Biocomplexity in the Environment: Coupled Biogeochemical Cycles Quantifying the Role of Mixing Interfaces in a Contaminated Aquifer-Wetland System: Linking Hydrogeological, Microbiological, & Geochemical Processes 10/04, $1,064,000 With Co-PIs I.M. Cozzarelli, M.A. Voytek, and M.S. Phanikumar.

Center for Environmental and Rural Health-NIH. Correlating Biogeochemical Processes at Mixing Interfaces within a Contaminated Aquifer-Wetland System, 07/03, $25,000.

Texas Water Resources Institute. Instrumentation to Measure Evolution of Gases from Subsurface Flow Constructed Wetlands, 05/03,$10,000.

Service and Professional Activities (Selected, Five Years)

2006- 2008 Environmental Programs Executive Committee
GESAA (Geochemistry of the Earth, Sea & Atmosphere) Advisory Council
CURRICULUM VITAE

John D. Vitek, Professor Emeritus & Adjunct Professor
Geology and Geophysics

Ph.D. (Geography) University of Iowa, Iowa City, 1973
M.A. (Geography) University of Iowa, Iowa City, 1970
B.S. (Mathematics & Geography) Wisconsin State University, Stevens Point, Wisconsin, 1964

Professional Experience

2008- retired Emeritus Professor and Adjunct in Geology & Geophysics
2005-08 Assistant Dean, Office of Graduate Studies, Texas A&M University
2003-05 Professor of Geology, Oklahoma State University; now Emeritus
2002-03 Interim Executive Vice President, August 2002 through June 2003
1997-02 Associate Vice President for Academic Affairs, July 1997
1992-95 Professor of Geology (inc. a 50% appointment with the NASA Aerospace Education Services Project)
1989-92 Associate Dean, Graduate College
1988-89 Assistant Dean, Graduate College
1982-88 Assistant Dean, Graduate College, Oklahoma State (50%)
1987-05 Professor of Geology, Oklahoma State University
1982-92 Coordinator of Environmental Sciences, Oklahoma State
1984-86 Professor of Geography, Oklahoma State University
1980-84 Associate Professor, Geography, Oklahoma State
1978-80 Assistant Professor, Geography, Oklahoma State
1974-78 Assistant Prof. Physical Geography, Univ. of Michigan, Flint, MI.
1976-77 Chairman Physical Geography, Univ. Michigan, Flint
1977 Visiting Asst. Prof. of Geology, Univ. of Michigan, Ann Arbor, Summer Field Camp, Jackson, WY
1971-74 Assistant Professor, Geography, State Univ. of New York, Buffalo, NY
1967-70 Part-time Instructor of Geography, Univ. of Iowa, Iowa City, Iowa
1965-67 Cartographer, Northern Illinois University, DeKalb, IL

Awards and Honors

1995 Elected Fellow, American Association for the Advancement of Science (AAAS Section E - Geology and Geography.
1994-98 Named Editor-in-Chief, Geomorphology (4 year appointment)
1992 Elected a Fellow in The Geological Society of America

Courses Taught

GEOL101 Introduction to Physical Geology (TAMU)
ENVIR6100 Seminar on Writing for Publication (OSU)
G-Camp for Teachers Summer Sessions of 2008 and 2009
Students Advised

Currently serving on committees for 5 MS students and 6 PhD students.

Recent Publications


Five Influential Publications


Hanson, S., J.D. Vitek, and P.O. Hanson (1979) Natural disaster - long-range impact on human response to future disaster threats, *Environment and Behavior*, 11, 268-284. 8 Citations (Nov 2009)
Appendix B. Undergraduate Program

B.1. Course Descriptions
Course Descriptions
Department of Geology and Geophysics

Geology (GEOL)

101. (GEOL 1103 and 1303, 1403) Principles of Geology. (3-3). Credit 4. I, II, S
Physical and chemical nature of the Earth and dynamic processes that shape it; plate tectonics, Earth’s interior, materials it is made of, age and evolution, earthquakes, volcanism, erosion and deposition; introduces physical and chemical principles applied to the Earth. Not open to students who have taken GEOL 103 or 104.

104. Physical Geology. (3-3). Credit 4. I
Earth materials, structures, external and internal characteristics; physical processes at work upon or within the planet; required for students in geology, geophysics and petroleum engineering. A working knowledge of high school chemistry and mathematics is required.*

106. (GEOL 1104 and 1304, 1404) Historical Geology. (3-3). Credit 4. I, II
Hypotheses of Earth’s origin; age dating of geologic materials; development and history of life; plate tectonic reconstructions, geologic history, and paleogeography, with emphasis on the North American plate. Prerequisite: GEOL 101 or equivalent.

203. Mineralogy. (2-6). Credit 4. I
Crystallography, crystal chemistry, mineral chemistry, optical crystallography, physical properties, and geologic occurrence of rock-forming and economic minerals. Prerequisites: GEOL 101, 104 or 320; CHEM 101; MATH 131 or 151 or approval of instructor.

Directed studies in specific problem areas of geology. Prerequisite: Approval of instructor.

Research conducted under the direction of faculty member in geology. May be repeated 2 times for credit. Prerequisites: Freshman or sophomore classification and approval of instructor.

300. Field Geology. Credit 6. S
Basic concepts of field relationships and field techniques are used to develop geologic maps, stratigraphic columns, cross-sections and geologic interpretations for a variety of geologic provinces. Course conducted off-campus in a field camp for six weeks. Prerequisites: GEOL 302, 306, 309, 312 or approval of instructor.*

301. Mineral Resources. (2-3). Credit 3. II
Origin, geologic relations and geographic distribution of mineral and energy resources; mineral economics, mining and reclamation and global economics in the resource industry; identification and classification of economic minerals including energy resources, base and precious metals, chemical industrial minerals and gemstones. Prerequisites: GEOL 101 or 320; CHEM 106 or higher.*

302. Introduction to Petrology. (3-3). Credit 4. II
Introduction to the origin and evolution of igneous, sedimentary, and metamorphic rocks; classification and petrographic analysis of major rock types; relationships to tectonic settings. Prerequisites: GEOL 104 and 203 or approval of instructor.
304. Igneous and Metamorphic Petrology. (3-3). Credit 4. I
Origin, identification and classification of igneous and metamorphic rocks; genetic processes inferred from laboratory studies and field occurrences. Prerequisites: GEOL 302 and 309 or approval of instructor.*

305. Paleobiology. (2-3). Credit 3. I
Principles of paleobiology; study of organisms important in the marine fossil record; application of paleontology to geologic problems. Prerequisite: GEOL 106 or approval of instructor.

306. Sedimentology and Stratigraphy. (3-3). Credit 4. II
Origin of sediments and sedimentary rocks; climate, weathering, and weathering products; transport, deposition, and depositional environments for sediments; field and laboratory studies in description and interpretation of genesis of sedimentary rocks; principles of stratigraphy and basin analysis; plate tectonics and the formation of sedimentary basins; stratigraphic nomenclature; geologic time and correlation; sequence stratigraphy and basin architecture. Prerequisites: GEOL 101 or 104 or approval of instructor.*

Evolutionary development of dinosaurs and Mesozoic geography, climate and terrestrial environments including dinosaur morphology; evolutionary relationships; dinosaur metabolism; and constraints imposed by gigantism; their latitudinal distribution; causal mechanism for dinosaur extinction.

308. Integrated Earth Science. (3-3). Credit 4. I,II
Integrated processes shaping Earth’s crust, continents, ocean basins, atmosphere and biosphere; place of Earth in the universe; relationship between Earth and human society; related fundamental physical and biological science principles and processes within an integrated Earth science context. Not an elective for students pursuing degrees for careers as professional geologists. Prerequisite: GEOL 101 or GEOG 203.*

309. Introduction to Geological Field Methods. (1-6). Credit 3. II
Geological mapping methods, field observation procedures and data gathering and recording; use of Brunton compass; pace-and-compass mapping; topographic map use and interpretation; measurement of structural elements; interpretation of geologic map patterns; measurement of stratigraphic sections; construction of geologic cross sections; six day geologic mapping project during either spring break or two three-day weekends. Prerequisites: GEOL 101 or 104; GEOL 106.*

310. Planetary Geology. (3-0). Credit 3.
Introduction to planetary science; organization and composition of the solar system, including the planets, satellites and asteroids; surface features and internal structures of the terrestrial planets and moons; the dynamic processes of planetary resurfacing, including volcanism, tectonism, weathering and impacts; the history and future of solar system exploration. Prerequisites: GEOL 101 or 104; junior or senior classification or approval of instructor.

Principles of writing for geological reports; format and style for abstracts, grant proposals, journal manuscripts and industry reports; evaluating written reports for revision and editing; using proper referencing and citation style; methods of maintaining clarity in documents; using web tools for geological communication.

312. Structural Geology and Tectonics. (3-3). Credit 4. II
Interpretation of rock structures; their relation to stratigraphic, physiographic and economic problems; regional tectonics of several selected areas. Prerequisites: GEOL 101, 104 or 320; approval of instructor.*
320. Geology for Civil Engineers. (2-3). Credit 3. I, II
Principles of physical and engineering geology; properties of minerals, rocks and soils; active surface and subsurface processes; applications to the siting, design, construction, operation and maintenance of engineered works and the protection of the environment. A three-day field trip is required (a field trip fee is charged at registration). Prerequisite: Sophomore classification.*

330. Geologic Field Trips. Credit 1 to 3.
Field trips to observe, analyze and interpret the geology and geophysics of selected localities in Texas and adjacent regions; complements classroom experience. Trip frequencies, duration, dates and study localities vary with semester. Prerequisite: GEOL 101 or 104 or approval of instructor. May be repeated for credit.*

352. GPS in the Geosciences. (1-3). Credit 2.
Introduction to the Global Positioning System (GPS); basic geodesy, figure of the earth; frames of reference, map projection, datums, ellipsoids; GPS accuracy and precision; applications in earth resource mapping and database creation; elementary GPS phase data processing. Prerequisites: Junior or senior classification; approval of instructor.

400. Reservoir Description. (2-3). Credit 3.
An integrated reservoir description experience for senior students in petroleum engineering, geology and geophysics; includes using geophysical, geological, petrophysical and engineering data; emphasis on reservoir description (reservoir and well data analysis and interpretation), reservoir modeling (simulation), reservoir management (production optimization) and economic analysis (property evaluation). Prerequisite: Junior or senior classification or approval of instructor. Cross-listed with PETE 400.

Origin, migration and accumulation of petroleum; typical U.S. oil and gas fluids; laboratory work in subsurface geology. Prerequisites: GEOL 312; senior classification in geology.

410. Hydrogeology. (3-0). Credit 3. I
Geologic conditions determining the distribution and movement of ground water and their effect on the hydrologic properties of aquifers. Prerequisite: Junior or senior classification or approval of instructor.

420. Environmental Geology. (2-2). Credit 3. II
Geologic concepts of the nature of geologic environments and the dynamics of geologic processes needed to characterize and quantify human interactions with specific geologic systems including aquifers, watershed, coastlines and wetlands; specific techniques, including geophysical and geochemical techniques, field mapping, geographical information systems and remote sensing used to monitor human-geosphere interactions. Prerequisites: GEOL 101 or GEOG 203; junior or senior classification or approval of instructor.

Fundamentals of soil, rock and fluid mechanics and basic engineering practices as applied to the analysis of the geologic environment for engineering uses. Designed for geoscience majors who have not had engineering courses. Prerequisites: GEOL 312 or approval of instructor; PHYS 218.*

451. Introduction to Geochemistry. (3-0). Credit 3. II
Chemical principles and processes responsible for the formation and cycling of earth materials, with emphasis on low temperature equilibria and kinetics in rock-water systems. Prerequisite: GEOL 302 or
approval of instructor.

Petrology, stratigraphy and structure of the oceanic and continental lithosphere relative to the unifying hypotheses of sea-floor spreading and plate tectonics; geological data integrated to provide coherent overview of the Earth’s crust. Prerequisites: GEOL 302 and 312 or approval of instructor. Offered irregularly as demand merits.

485. Directed Studies. Credit 1 or more each semester. I, II, S
Advanced problems in geology.

489. Special Topics in... Credit 1 to 4.
Selected topics in an identified area of geology. May be repeated for credit. Prerequisite: Approval of instructor.

491. Research. Credit 1 to 4.
Research conducted under the direction of faculty member in geology. May be repeated 2 times for credit. Prerequisites: Junior or senior classification and approval of instructor.

*Field trips ma

Geophysics (GEOP)

Introduction to geology and geophysics of Earth’s Moon, as compared with Earth; origin of terrestrial planets; origin of the moon; physics of meteor impact; tectonics and volcanism; gravity anomalies; paleomagnetism; Moon’s geologic history; relatively non-technical course. Prerequisite: GEOL 101 or equivalent or approval of instructor.

Research conducted under the direction of faculty member in geophysics. May be repeated 2 times for credit. Prerequisites: Freshman or sophomore classification and approval of instructor.

341. Introduction to Global Geophysics. (3-0). Credit 3.
Introduction to the structure, composition and evolution of the Earth as inferred by geophysical methods; seismology, gravity and geodesy, magnetics, heat flow and concepts of plate tectonics. Prerequisites: GEOL 101 or 104; MATH 131 or 151; or approval of instructor.

413. Near-surface Geophysics. (3-0). Credit 3, II
Fundamentals of traditional and emergent surface and borehole geophysical methods, as they are applied to shallow (less than 100 meters) subsurface investigations; emphasis on electrical, magnetic and electromagnetic methods; seismic reflection and crosswell tomography. Prerequisites: GEOL 101 or 104; MATH 251; PHYS 219; or approval of instructor.

421. Petroleum Seismology I. (3-3). Credit 4, I
Physical principles behind seismic acquisition; acoustic/elastic, homogeneous/heterogeneous, onshore/offshore/transition zones; description of seismic data, pre- and post- critical reflections, multiples, ground roll; signal processing for seismic data analysis; Fourier transforms, wavelet transform, correlation and smoothness; least squares optimization; forward and inverse problems fitting a Fourier series, deconvolution. Prerequisites: MATH 151 and 152 or approval of instructor.
Introduction to theory of gravity, magnetic, electrical and seismic exploration methods; physical
properties of earth materials and their influence on geophysical measurements; limitations of geophysical
data in the interpretation of subsurface structure. Prerequisites: GEOL 309; MATH 251; PHYS 219.*

470. Computational Methods in Geology and Geophysics. (3-0). Credit 3.
Introduction to a variety of computational tools for solving common quantitative problems in geophysics
and geology; statistical description and modeling of data sets; techniques for forward modeling
geophysical processes, including gravity and magnetics, fluid flow, and heat and chemical transport;
elementary inverse modeling of geophysical data sets. Prerequisites: GEOL 101 or 104; MATH 308; or
approval of instructor.

475. Interpretation of Gravity and Magnetic Fields. (3-0). Credit 3.
Applications of potential theory in the interpretation of gravity and magnetic fields; analysis of
geophysical anomalies produced by geologic structures and by variation in the physical properties of
rocks; use of regional gradients, residual anomalies, higher derivatives and surfaces, line integrals and
two and three dimensional models. Prerequisites: GEOL 312; MATH 311 or approval of instructor.

485. Directed Studies. Credit 1 or more each semester. I, II, S
Advanced problems in geophysics.

491. Research. Credit 1 to 4.
Research conducted under the direction of faculty member in geophysics. May be repeated 2 times for
credit. Prerequisites: Junior or senior classification and approval of instructor.
*Field trips may be required for which departmental fees may be assessed to cover costs.
B.2. Undergraduate Students Engaged in Research
Atkinson, Clint Continuation of Project to Date Detrital Zircons of the Wilcox Group and Overlying Strata, project just starting.

Advisors: Yancey, T.E. and B.V. Miller

Beck, Courtney (Fall 2009) Determination of Values of aH$_2$O in Amphibole-Bearing Mantle Xenoliths from South Africa.


Becker, Andrew (Candidate, B.S. Geology, expected December 2009)
Preparing proposal to study Fault Complexity in the San Gabriel Mountains, using recent LiDAR combined with field mapping. Proposal will be submitted to NCALM Seed Proposal from Graduate Students, Nov. 2009. Also applied to attend Workshop: Using GeoEarthScope and B4 LiDAR data to analyze Southern California’s active faults, A Joint SCEC-OpenTopography-USGS-UNAVCO Research and Education Workshop, December 3 and 4, 2009 @ San Diego Supercomputer Center, Workshop Organizers: J Ramón Arrowsmith, Arizona State University, Christopher Crosby, San Diego Supercomputer Center - Open Topography, Ken Hudnut, US Geological Survey, Susan Eriksson, UNAVCO

Advisors: Chester, F.M. and J.S. Chester
Candidate, B.S. Geology, expected December 2009

Beveridge, C. Geol. 485, Planktonic Foraminifera from Site 1237. Texas A&M University

Advisor: Wade, B.S..

Bishop, John (2009) AVO Analysis of Marine CSEM data, TAMU PETE senior project,

Advisor: M.E. Everett

Burns, Krista (lab assistant, 2008-present)

Grossman

Crislip, P.S. Experimental Determination of Rates of Molluscan Shell Destruction (Aransas Bay, Texas)

Advisor: Olszewski, T.D.

Ford, S. (UG student) Fabric and Microstructure Evolution of Dolomite - Shear Experiments (GEOL 491)

Advisor: Newman, J.

Franklin, Alyssa Neodymium isotopes and deglacial intermediate water flow in the Florida Straits

Advisors Marcantonio, F.

Frazier, Colin (lab assistant, 2008-present)
Advisor: Grossman

   Advisor: Bruce Herbert
   Placement upon Graduation: Graduate school at Texas A&M.

Hutto, A.P. *Detrital Zircon Dating of Wilcox Group Sediments for Provenance Determination*, part of the Undergraduate Research Scholars Program, TAMU, results presented at Gulf Coast Association of Geological Societies annual meeting and published as an extended abstract.
   Advisors: Yancey, T.E. and B.V. Miller
   Placement on Graduation: probably University of Arizona

Jordan, Ashley. Undergraduate – Department of Geology and Geophysics, *Geochemistry laboratory assistant*, employed on research grant
   Advisor: Miller B.

   Advisors: Tice, M., and Sparks, D. W.


Munoz, Andrew (Undergraduate Research Scholar, 2009-2010): *Modeling of Tsunami Inundation with GPU-SPHysics*
   Advisor: Weiss, R.

O’Shay, Justin (Major: Geophysics): *Modeling the Leading Tsunami Waves due to Landslides.*
   Advisor: Weiss, R.

   Advisor: Bruce Herbert
   Placement upon Graduation: Applying to graduate school.

Seitz, K.E. *Lower Permian Fossil Communities of the Council Grove Group, Kansas*
   Advisor: Olszewski, T.D.

   Advisor: Pope, M. C.
   Placement upon Graduation: University of Texas

Tengku Shaifula, F., (B. S. Geology, 2010) Thermal Evolution and Convection in Icy Planetesimals

   Advisors: Sparks, D. W.


   Advisor: Raymond, A.
   Placement upon Graduation: M.S. program (Sedimentology) Texas A&M University

2008

Becker, Andrew (Candidate, B.S. Geology, expected December 2009)

   Worked on NSF Grant EAR- 0643339 (RF- 496421), Collaborative Research: Influence of Structure, Composition and Fluid-rock Chemistry on Mode of Slip in the San Andreas Fault Zone at SAFOD (6/07-5/09, extended to 5/2010). Co-PIs: F.M. Chester, J.P. Evans (Utah State University), D. Kirschner (Saint Louis University), $399,021 total, $201,398 (TAMU budget), partial for one undergraduate student, Andrew Becker, and three graduate students, Bretani Heron, David Sills, and Clayton Coble.

   Advisors: Chester, F.M. and J.S. Chester
   Candidate, B.S. Geology, expected December 2009

Bowden, S.C., Geol. 485, Lithologic Change at Site 242. Texas A&M University.

   Advisor: Wade, B.S..


   Advisor: Bruce Herbert
   Placement upon Graduation: Employment as a statistician at USDA.

Davis, V. (BS Geology student), Directed Studies in Petroleum Geology, GEOL485-630

   Project Advisor(s): Sun, Y.


   Advisor: M.M. Tice
   Placement upon Graduation: University of Oklahoma

Advisor: Bruce Herbert
Placement upon Graduation: Graduate school at Texas A&M.

Advisor: M.M. Tice

Horbaczewski, A.M. *Copano Bay: Assessing the Accountability of Spatial/temporal Variability in Benthic Molluscan Paleocommunities*
Advisor: Olszewski, T.D.
Placement upon Graduation: New Mexico Institute of Mining and Technology

Advisors Marcantonio, F.

Advisors: Grossman, E.L. and T.E. Yancey
Placement upon Graduation: SMU


Project Advisor(s): Sun, Y.
Placement upon Graduation: Colorado School of Mines (M.S. student, 2009)

Advisor: Bruce Herbert
Placement upon Graduation: Graduate school at Texas A&M.

2007

Advisor: Zhan, H.
Placement upon Graduation: Graduate Student at University of Wisconsin-Madison.

Farrell, L. (B.S. Geophysics, 2007) *Thermal Evolution and Differentiation of Asteroids*
Advisors: Sparks, D. W.
Placement upon Graduation: Rice University

McGary, R.S., *Geophysical Characterization of the Meteorite Impact Site at Odessa TX*,
GEOP485, Advisor: M.E. Everett

McGary, R. S. (B.S. Geophysics, 2007) *Thermal Evolution and Differentiation of Asteroids*

Advisors: Sparks, D.W.
Placement upon Graduation: Woods Hole Joint Program and Massachusetts Institute of Technology

McGroarty, M. (UG student) *Deformation Along Peridotite Shear Zones* GEOL 485

Advisor: Newman, J.


Advisor: Carlson, R.L.
Placement upon graduation: University of Washington


Advisor: Bruce Herbert
Placement upon Graduation: Graduate school at UC Santa Barbara (MS) and UCLA (PhD).


Advisor: Bruce Herbert
Placement upon Graduation: Graduate school at Texas A&M.

Terrette, Lacy (lab assistant, 2007-2008)

Advisor: Grossman

2006


Advisor Carlson, R.L
Placement upon graduation: Aramco, Saudi Arabia

Bagley, B. (B.S. Geophysics, 2006), *Seismic Discontinuities in the Mantle Beneath the Western Pacific: Evidence from ScS Reverberations,* Undergraduate Research Scholars Program, based on Univ. Minnesota Summer Internship with J. Revenaugh

Advisors: Sparks, D. W.
Placement upon Graduation: University of Minnesota

Haecker, Adam. Undergraduate – Department of Geology and Geophysics, *Undergraduate research assistant,* employed on research grant
Miller, B.

McGroarty, M. (UG student) *Deformation Along Peridotite Shear Zones*  NSF EAR Grant 0409567
Advisor: Newman, J.

Schneider, S. (B.S. Geophysics, 2006), *The Effect of Deformation on Grain Boundary Wetness in Partially Molten Peridotite*, Undergraduate Research Scholars Program, based on Univ. Minnesota Summer Internship with D. Kohlstedt
Advisors: Sparks, D. W.
Placement upon Graduation: University of Minnesota

Advisor: Bruce Herbert

Sou, N., Aresty Sophomore Research Assistant Program, Rutgers University
Advisor: Wade, B.S..

Takaichi, Mike (2006) *Mg/Ca-derived SSTs in Arabian Sea sediments*
Advisors Marcantonio, F.

**2005**

Bowden, Clay. Undergraduate – Department of Geology and Geophysics, *Undergraduate research assistant*, employed on research grant
Advisor: Miller, B.

Levitt, Joe (2005) *Pb Isotope Study of Sediments from Lake Maurepas, Louisiana*
Advisors Marcantonio, F.

Advisor: Carlson, R.L.
Placement upon graduation: UCSD Scripps Institution of Oceanography

Advisor: David Wiltschko
Currently: PhD student, Indiana University

Waller, Troy (B.S. Geology 2005, M.S. Geology TAMU 2007, Currently with Hess Corporation)
Worked on NSF Grant EAR-0454525 (RF-467711), *Collaborative Research: Structural-Petrologic Characterization of the San Andreas Fault Zone in the SAFOD Drill Holes* (6/05-5/08) Co-PIs: F.M. Chester, J. P. Evans (Utah State University), D. Kirschner (Saint Louis University), $244,975 total, $119,982 (TAMU budget), partial funding for two undergraduate students, Andrew Becker and T.J. Waller, and three graduate students, Rafael Almeida, Tersa Sabato Ceraldi, and Hiroko Kitajima

Advisors: Chester, F.M. and J.S. Chester

Current Employer: Hess Corporation
B.3. Undergraduate Program Assessment Plan
Texas A&M University

Detailed Assessment Report
2008-2009 Geology, BA

Mission/Purpose

The Department of Geology and Geophysics is dedicated to the scientific study of all aspects of the solid Earth, from fundamental processes that shape it to knowledge that benefits society. The BA in Geology provides a foundation in geology for students who will enter science-related careers, such as environmental law, pre-college teaching, science journalism, and resource management and marketing. Graduates will supplement their curriculum in geology with a minor designed around their career goals.

Student Learning Outcomes, with Any Associations and Related Measures, Findings, and Action Plans

01: Knowledge of geologic fundamentals
Graduates will have a broad understanding of geologic processes and Earth materials

Associations:

General Education or Core Curriculum:
1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

Related Measures:

M1: Capstone exam
Students will take an online capstone exam (triggered by completing four core required courses) that tests basic skills and ability to solve geologic problems.

Source of Evidence: Comprehensive/end-of-program subject matter exam

Achievement Target:
80% of students will answer 75% of questions correctly

Findings (2008-2009) - Achievement Target: Not Met
2 of the 3 BA graduates in Spring 2009 took the exam. Their scores were 47% and 44%

Related Action Plans:

Review & revise capstone exam
Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.

For more information, see the Action Plan Details section of this report.

O 2: Knowledge transfer from other sciences
Students will be able to apply basic mathematical analysis to fundamental geological problems

Associations:

General Education or Core Curriculum:
1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

Related Measures:

M 1: Capstone exam
Students will take an online capstone exam (triggered by completing four core required courses) that tests basic skills and ability to solve geologic problems.

Source of Evidence: Comprehensive/end-of-program subject matter exam

Achievement Target:
80% of students will answer 75% of questions correctly

Findings (2008-2009) - Achievement Target: Not Met
2 of the 3 BA graduates in Spring 2009 took the exam. Their scores were 47% and 44%

Related Action Plans:

Review & revise capstone exam
Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.

For more information, see the Action Plan Details section of this report.

O 3: Knowledge transfer to non-science fields
Graduates will be able to apply their geologic knowledge to their chosen concentration field

Associations:

General Education or Core Curriculum:
1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

Related Measures:

M 1: Capstone exam
Students will take an online capstone exam (triggered by completing four core required courses) that tests basic skills and ability to solve geologic problems.

Source of Evidence: Comprehensive/end-of-program subject matter exam
Achievement Target:
80% of students will answer 75% of questions correctly

Findings (2008-2009) - Achievement Target: Not Met
2 of the 3 BA graduates in Spring 2009 took the exam. Their scores were 47% and 44%

Related Action Plans:
- Review & revise capstone exam
  Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.
  For more information, see the Action Plan Details section of this report.

O 4: Communication Skills
Graduates will be able to express thoughts and ideas in writing in a clear and logical manner

Associations:
- General Education or Core Curriculum:
  3 Communicate effectively in writing and speaking

Related Measures:

M 4: Writing assignments
Students' papers and reports prepared in Geology and Geophysics courses will be selected and evaluated for clear and effective communication

Source of Evidence: Written assignment(s), usually scored by a rubric

Achievement Target:
100% of graduates will demonstrate the ability to communicate concepts and ideas clearly and effectively

Findings (2008-2009) - Achievement Target: Met
Our departmental W course consists of students from all 3 majors (Geol BA, Geol BS, and Geop BS). Papers from 18 students in that course were included in the OIA/UWC university-wide assessment process. The results are as follows, with the university-wide results in parentheses. Aim = 2.417 (2.427); Development = 2.222 (2.175); Style = 2.111 (2.034); Organization = 2.167 (2.183); Conventions = 1.833 (1.972). The Overall Assessment = 2.150 (2.158) is slightly higher than the 2.0 value for "Meets Expectations ".

Other Outcomes/Objectives, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans

O 5: Placement in jobs
Graduates will gain employment in their chosen field, or enter a professional/graduate school program.

Related Measures:
M 2: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.
Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
80% of students will complete both surveys

Findings (2008-2009) - Achievement Target: Partially Met
For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. For all students graduating during the year, 14/28 = 50% completed the survey. Of those responding, 43% accepted permanent employment in the geoscience field (or as commissioned officer if COC), and 43% were accepted into graduate programs.

Related Action Plans:
Improve exit survey
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

For more information, see the Action Plan Details section of this report.

M 3: Graduate tracking
The Department will collect data on students career path.
Source of Evidence: Job placement data, esp. for career/tech areas

Achievement Target:
75% of graduates will enroll in a graduate or professional program, or begin careers in science-related fields

Findings (2008-2009) - Achievement Target: Met
For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. Of those responding, 43% accepted permanent employment in the geoscience field (or as commissioned officer if COC), and 43% were accepted into graduate programs.

Related Action Plans:
Improve exit survey
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

For more information, see the Action Plan Details section of this report.
O 6: Positive undergraduate experience
Students will feel valued and challenged by the faculty and fellow students, and develop into advocates for the program

Strategic Plans:
Texas A&M University
3 Enhance the Undergraduate Academic Experience.

Related Measures:

M 2: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
80% of students will complete both surveys

Findings (2008-2009) - Achievement Target: Partially Met
For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. For all students graduating during the year, 14/28 = 50% completed the survey. Responses: the program: a) prepared student for future career: strongly agree 22%, agree 64%, not sure 14%. b) was a positive professional experience: strongly agree 57%, agree 43%. c) was a positive personal experience: strongly agree 57%, agree 36%, not sure 7%

Related Action Plans:
Improve exit survey
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

For more information, see the Action Plan Details section of this report.

Details for Action Plans Established This Cycle

Improve exit survey
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

Priority: High
Target Date: 09/2009
We will start the process during the Fall semester 2009

Review & revise capstone exam
Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.

**Priority:** High

**Target Date:** 09/2009

Review will begin during Fall 2009

### Analysis Answers

For Student Learning Outcomes: Based on the assessment findings, what changes will be made to enhance student learning?

The results from this cycle are limited by the relatively low response to the exit survey and poor performance on the capstone exam. Until we obtain a better response to the survey, and review the content of the capstone exam, any possible changes to student learning cannot be evaluated. Enhancements to student learning will have to wait until the end of the next cycle.

For Program Outcomes: What changes will be made to the program as a result of your assessment of other program outcomes?

Not Applicable

**Assessment Process:** Reflecting on the program’s assessment process, what changes do you intend to make to the assessment plan?

1) a) increase the % of graduating seniors who participate in the exit survey. b) revise exit survey form to distinguish between Geol BA, Geol BS, and GeoP BS majors. 2) review the content of the capstone exam.

### Annual Reports

**Program Contributions**

During this cycle, the results for graduating seniors in the Geol BA, Geol BS, and GeoP BA were not separated. However, the overall results for the combined group show generally high satisfaction with the programs, both professionally and personally. A large proportion of the graduates (86%) report in the exit survey that they have obtained employment as professional geoscientists or have entered graduate programs. Although not specifically targeted for the BA assessment process, 37% of our undergraduate BA majors participated in research or directed studies during 2008-09.

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**Detailed Assessment Report**

2008-2009 Geology, BS

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**Mission/Purpose**
The Department of Geology and Geophysics is dedicated to the scientific study of all aspects of the solid Earth, from fundamental processes that shape it to knowledge that benefits society. The BS in Geology program fosters critical thinking, and the application of scientific skills to the study of earth materials and geologic processes. Graduates will be prepared for careers in the energy and environmental industries, and for advanced study at top-ranked graduate programs.

Student Learning Outcomes, with Any Associations and Related Measures, Findings, and Action Plans

O 1: Knowledge of geologic fundamentals
Graduates will have a broad understanding of geologic processes and Earth materials

Associations:

General Education or Core Curriculum:
1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

Related Measures:

M 1: Capstone Exam
Students will take an online capstone exam (triggered by completing four core required courses) that tests basic skills and ability to solve geologic problems.

Source of Evidence: Comprehensive/end-of-program subject matter exam

Achievement Target:
80% of students will answer 75% of questions correctly

Findings (2008-2009) - Achievement Target: Not Met
Of the 10 Spring 2009 BS graduates, 100% took the capstone exam. Results were: score 75-70%, 10% of students; score 60-70%, 20% of students; score 50-60%, 10% of students; score 40-50%, 30% of students; score 30-40%, 30% of students.

Related Action Plans:

Review capstone exam
Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.

For more information, see the Action Plan Details section of this report.

M 2: Field Camp Capstone Course
Projects from summer field camp (Geol 300) assess students’ ability to apply fundamental geologic knowledge to real geologic problems and data.

Source of Evidence: Capstone course assignments measuring mastery

Achievement Target:
Graduates must pass Geol 300
Findings (2008-2009) - Achievement Target: Met
All students passed Field Camp (Geol 300) in Summer of 2008. Review of 10 random samples of the capstone mapping project for the course by 2 independent faculty members resulted in a passing grade for all students.

M 7: ENG OPT--ASBOG licensure exam
Students will take an independently administered engineering geology exam (Association of State Boards of Geology, or ASBOG) to become licensed as Professional Geologists in the State of Texas.

Source of Evidence: Certification or licensure exam, national or state

Achievement Target:
70% of student will pass the licensure exam on their first attempt

Findings (2008-2009) - Achievement Target: Not Met
The 2 graduates in the Engineering Option enrolled in graduate programs and have not yet taken the ASBOG licensure exam.

O 2: Knowledge transfer from other sciences
Students will be able to apply basic mathematical analysis to fundamental geological problems

Associations:
General Education or Core Curriculum:
1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

Related Measures:

M 1: Capstone Exam
Students will take an online capstone exam (triggered by completing four core required courses) that tests basic skills and ability to solve geologic problems.

Source of Evidence: Comprehensive/end-of-program subject matter exam

Achievement Target:
80% of students will answer 75% of questions correctly

Findings (2008-2009) - Achievement Target: Not Met
Of the 10 Spring 2009 BS graduates, 100% took the capstone exam. Results were: score 75-70%, 10% of students; score 60-70%, 20% of students; score 50-60%, 10% of students; score 40-50%, 30% of students; score 30-40%, 30% of students.

Related Action Plans:
Review capstone exam
Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.

For more information, see the Action Plan Details section of this
report.

M 7: ENG OPT-ASBOG licensure exam

Students will take an independently administered engineering geology exam (Association of State Boards of Geology, or ASBOG) to become licensed as Professional Geologists in the State of Texas.

Source of Evidence: Certification or licensure exam, national or state

Achievement Target:

70% of student will pass the licensure exam on their first attempt

Findings (2008-2009) - Achievement Target: Not Met
The 2 graduates in the Engineering Option enrolled in graduate programs and have not yet taken the ASBOG licensure exam.

O 3: Field skills

Students will be able to collect and analyze geologic data, and use it to construct a geologic map

Associations:

General Education or Core Curriculum:

1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

Related Measures:

M 2: Field Camp Capstone Course

Projects from summer field camp (Geol 300) assess students’ ability to apply fundamental geologic knowledge to real geologic problems and data.

Source of Evidence: Capstone course assignments measuring mastery

Achievement Target:

Graduates must pass Geol 300

Findings (2008-2009) - Achievement Target: Met
All students passed Field Camp (Geol 300) in Summer of 2008.
Review of 10 random samples of the capstone mapping project for the course by 2 independent faculty members resulted in a passing grade for all students.

O 4: Communication Skills

Graduates will be able to express thoughts and ideas in writing in a clear and logical manner

Associations:

General Education or Core Curriculum:

3. Communicate effectively in writing and speaking

Related Measures:

M 3: Writing assignments

Students' papers and reports prepared in Geology or Geophysics courses will
be selected and evaluated for clarity and effective communication

Source of Evidence: Written assignment(s), usually scored by a rubric

**Achievement Target:**
100% of graduates will demonstrate the ability to communicate concepts and ideas clearly and effectively

**Findings (2008-2009) - Achievement Target: Met**
Our departmental W course consists of students from all 3 majors (Geol BA, Geol BS, and Geop BS). Papers from 18 students in that course were included in the OIA/UVIC university-wide assessment process.

The results are as follows, with the university-wide results in parentheses. Aim = 2.417 (2.427); Development = 2.222 (2.175); Style = 2.111 (2.034); Organization = 2.167 (2.183); Conventions = 1.833 (1.972). The Overall Assessment = 2.150 (2.158) is slightly higher that the 2.0 value for "Meets Expectations ".

**O 5: Research experience**
The department will encourage an increase in the number of undergraduates participating in research projects

**Associations:**

General Education or Core Curriculum:

1. Demonstrate critical analysis skills
2. Communicate effectively in writing and speaking

**Strategic Plans:**

Texas A&M University
3. Enhance the Undergraduate Academic Experience.

**Related Measures:**

**M 4: Student Exit and Entrance surveys**
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**
80% of students will complete both surveys

**Findings (2008-2009) - Achievement Target: Partially Met**
For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geop BS Majors. For all students graduating during the year, 14/28 = 50% completed the exit survey.

**M 5: Research Experience Tracking**
The Department will collect data on students enrolling in 485, 291 or 491 courses, employed in funded research projects, and presenting at professional conferences

Source of Evidence: Existing data

**Achievement Target:**
20% of undergraduates will participate in an ongoing research project

**Findings (2008-2009) - Achievement Target: Met**
For upper-level students in the Geol BS major, during the 2008-09 academic year, 35% were enrolled in an undergraduate research course, a directed studies course, or were student workers on research grants or in departmental laboratories.

**O 9: ENG OPT—Knowledge in engineering geology**
Graduates will have a foundation in the geotechnical evaluation and physics and chemistry of groundwater and soils

**Associations:**

**General Education or Core Curriculum:**
1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

**Related Measures:**

**M 7: ENG OPT—ASBOG licensure exam**
Students will take an independently administered engineering geology exam (Association of State Boards of Geology, or ASBOG) to become licensed as Professional Geologists in the State of Texas.

Source of Evidence: Certification or licensure exam, national or state

**Achievement Target:**
70% of student will pass the licensure exam on their first attempt

**Findings (2008-2009) - Achievement Target: Not Met**
The 2 graduates in the Engineering Option enrolled in graduate programs and have not yet taken the ASBOG licensure exam.

**Other Outcomes/Objectives, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans**

**O 6: Career Development**
The Department will encourage an increase in the number of undergraduate students taking Internships with Energy Companies, Environmental Firms, and Governments Laboratories

**Associations:**

**Institutional Priorities:**
4. Expand off-campus opportunities, such as internships, study-abroad, and service-learning.

**Strategic Plans:**
- Texas A&M University
  3. Enhance the Undergraduate Academic Experience.
M 4: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
10% of undergraduate students will take a summer internship in an energy company, environmental firm, or government laboratory

Findings (2008-2009) - Achievement Target: Met
Of the students completing the exit survey, 29% of graduating seniors in all majors held a summer internship during their education.

Related Action Plans:
Improve exit survey
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

For more information, see the Action Plan Details section of this report.

O 7: Placement in jobs/graduate schools
Graduates will be accepted to and enroll in competitive graduate programs or gain employment as professional geologists.

Related Measures:

M 4: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
80% of students will complete both surveys

Findings (2008-2009) - Achievement Target: Partially Met
For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. For all students graduating during the year, 14/28 = 50% completed the survey. Of those responding, 43% accepted permanent employment in the geoscience field (or as commissioned officer if COC), and 43% were accepted into graduate programs.

Related Action Plans:
Improve exit survey
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the
forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geol BS.

For more information, see the Action Plan Details section of this report.

M 6: Graduate tracking
The Department will collect data on students career path.

Source of Evidence: Job placement data, esp. for career/tech areas

Achievement Target:
75% of graduates will enroll in a graduate or professional program, or begin careers as professional geologists

Findings (2008-2009) - Achievement Target: Met
For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. For all students graduating during the year, 14/28 = 50% completed the survey. Of those responding, 43% accepted permanent employment in the geoscience field (or as commissioned officer if COC), and 43% were accepted into graduate programs.

M 7: ENG OPT – ASBOG licensure exam
Students will take an independently administered engineering geology exam (Association of State Boards of Geology, or ASBOG) to become licensed as Professional Geologists in the State of Texas.

Source of Evidence: Certification or licensure exam, national or state

Achievement Target:
70% of student will pass the licensure exam on their first attempt

Findings (2008-2009) - Achievement Target: Not Met
The 2 graduates in the Engineering Option enrolled in graduate programs and have not yet taken the ASBOG licensure exam.

O 8: Positive undergraduate experience
Students will feel valued and challenged by the faculty and fellow students, and develop into advocates for the program

Strategic Plans:
Texas A&M University
3 Enhance the Undergraduate Academic Experience.

Related Measures:

M 4: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
80% of students will complete both surveys
**Findings (2008-2009) - Achievement Target: Partially Met**

For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. For all students graduating during the year, 14/28 = 50% completed the survey. Responses: the program: a) prepared student for future career: strongly agree 22%, agree 64%, not sure 14%. b) was a positive professional experience: strongly agree 57%, agree 43%. c) was a positive personal experience: strongly agree 57%, agree 36%, not sure 7%

**Related Action Plans:**

**Improve exit survey**

We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

For more information, see the Action Plan Details section of this report.

**Details for Action Plans Established This Cycle**

**Improve exit survey**

We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

**Priority:** High

**Target Date:** 09/2009

We will begin the process during Fall 2009

**Review capstone exam**

Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.

**Priority:** High

**Target Date:** 09/2009

We will begin the revised process starting in Fall 2009

**Analysis Answers**

*For Student Learning Outcomes: Based on the assessment findings, what changes will be made to enhance student learning?*

The results from this cycle are limited by the relatively low response to the exit survey and poor performance on the capstone exam. Until we obtain a better response to the survey, and review the content of the capstone exam, any possible
changes to student learning cannot be evaluated. Enhancements to student learning will have to wait until the end of the next cycle.

For Program Outcomes: What changes will be made to the program as a result of your assessment of other program outcomes?

Not Applicable

Assessment Process: Reflecting on the program’s assessment process, what changes do you intend to make to the assessment plan?

1) a) increase the % of graduating seniors who participate in the exit survey. b) revise exit survey form to distinguish between Geol BA, Geol BS, and Geop BS majors. 2) review the content of the capstone exam.

Annual Reports

Program Contributions

During this cycle, the results for graduating seniors in the Geol BA, Geol BS, and Geop BA were not separated. However, the overall results for the combined group show generally high satisfaction with the programs, both professionally and personally. A large proportion of the graduates (96%) report in the exit survey that they have obtained employment as professional geoscientists or have entered graduate programs. The proportion of our upper-level Geol BS majors involved in research and directed studies (35%) far exceeded our expectations.

Detailed Assessment Report
2008-2009 Geophysics, BS

Mission/Purpose

The Department of Geology and Geophysics is dedicated to the scientific study of all aspects of the solid Earth, from fundamental processes that shape it to knowledge that benefits society. The objective of the BS in Geophysics program is to develop a physically-motivated approach to the study of Earth phenomena, through treatment of physical and geological principles and development of mathematical tools. Graduates will be well-prepared for careers in the energy and
environmental industries, and for advanced study at top-ranked graduate programs.

Student Learning Outcomes, with Any Associations and Related Measures, Findings, and Action Plans

O 1: Knowledge of geologic and geophysical fundamentals
Graduates will have a broad understanding of geologic processes and Earth materials

Associations:
General Education or Core Curriculum:
1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

Related Measures:
M 1: Capstone exam
Students will take an online capstone exam (triggered by completing four core required courses) that tests basic skills and ability to solve geologic and geophysical problems.

Source of Evidence: Comprehensive/End-of-Program subject matter exam

Achievement Target:
80% of students will answer 75% of questions correctly

Findings (2008-2009) - Achievement Target: Not Met
1 of 2 = 50% of the Spring 2009 Geop BS graduates took the capstone exam, and scored 35%.

Related Action Plans:
Review capstone exam
Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.

For more information, see the Action Plan Details section of this report.

O 2: Knowledge transfer from other sciences
Students will be able to apply basic mathematical analysis to fundamental geological problems

Associations:
General Education or Core Curriculum:
1. Master the depth of knowledge required of a discipline
2. Demonstrate critical analysis skills

Related Measures:
M 1: Capstone exam
Students will take an online capstone exam (triggered by completing four core
required courses) that tests basic skills and ability to solve geologic and
geophysical problems.
Source of Evidence: Comprehensive/end-of-program subject matter exam

Achievement Target:
80% of students will answer 75% of questions correctly

Findings (2008-2009) - Achievement Target: Not Met
1 of 2 = 50% of the Spring 2009 Geop BS graduates took the capstone
texam, and scored 55%.

Related Action Plans:
Review capstone exam
Faculty who provided questions for the capstone exam will review
the questions in light of the results to verify that questions are
relevant and valid.

For more information, see the Action Plan Details section of this
report.

O 3: Communication Skills
Graduates will be able to express thoughts and ideas in writing in a clear and
logical manner

Associations:

General Education or Core Curriculum:

3 Communicate effectively in writing and speaking

Related Measures:

M 2: Writing Assignments
Students' papers and reports prepared in Geology or Geophysics courses will
be selected and evaluated for clarity and effective communication

Source of Evidence: Written assignment(s), usually scored by a rubric

Achievement Target:
100% of graduates will demonstrate the ability to communicate concepts
and ideas clearly and effectively

Findings (2008-2009) - Achievement Target: Met
Our departmental W course consists of students from all 3 majors (Geol
BA, Geol BS, and Geop BS). Papers from 18 students in that course
were included in the OIA/UMC university-wide assessment process.
The results are as follows, with the university-wide results in
parentheses. Aim = 2.417 (2.427); Development = 2.222 (2.175); Style =
2.111 (2.034); Organization = 2.167 (2.183); Conventions = 1.833
(1.972). The Overall Assessment = 2.150 (2.158) is slightly higher that
the 2.0 value for "Meets Expectations ".

O 4: Research experience
The department will encourage an increase in the number of undergraduates
participating in research projects
**Associations:**

**General Education or Core Curriculum:**

2. Demonstrate critical analysis skills  
3. Communicate effectively in writing and speaking

**Strategic Plans:**

Texas A&M University  
3. Enhance the Undergraduate Academic Experience.

**Related Measures:**

**M 3: Student Exit and Entrance surveys**

The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**

80% of students will complete both surveys

**Findings (2008-2009) - Achievement Target: Partially Met**

For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. For all students graduating during the year, 14/28 = 50% completed the survey.

**Related Action Plans:**

**Improve exit survey**

We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

For more information, see the Action Plan Details section of this report.

**M 4: Research experience tracking**

The Department will collect data on students enrolling in 485, 291 or 491 courses, employed in funded research projects, and presenting at professional conferences.

Source of Evidence: Existing data

**Achievement Target:**

20% of undergraduates will participate in an ongoing research project

**Findings (2008-2009) - Achievement Target: Met**

For upper-level students in the Geop BS major, during the 2008-09 academic year, 37% were enrolled in an undergraduate research course, a directed studies course, or were student workers on research grants or in departmental laboratories.

**Other Outcomes/Objectives, with Any Associations and Related**
Measures, Achievement Targets, Findings, and Action Plans

O 5: Career Development
The Department will encourage an increase in the number of undergraduates taking summer internships with energy companies, environmental firms, or government laboratories

**Associations:**

**Institutional Priorities:**

4  Expand off-campus opportunities, such as internships, study-abroad, and service-learning.

**Strategic Plans:**

Texas A&M University
3 Enhance the Undergraduate Academic Experience.

**Related Measures:**

M 3: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**
10% of undergraduate students will take a summer internship in an energy company, environmental firm, or government laboratory

**Findings (2008-2009) - Achievement Target: Met**
Of the students completing the survey, 29% of graduating seniors in all majors hold a summer internship during their education.

**Related Action Plans:**

**Improve exit survey**
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

For more information, see the Action Plan Details section of this report.

O 6: Placement in jobs/graduate schools
Graduates will be accepted to and enroll in competitive graduate programs or gain employment as professional geologists.

**Related Measures:**

M 3: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.
Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**
80% of students will complete both surveys

**Findings (2008-2009) - Achievement Target: Partially Met**
For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. For all students graduating during the year, 14/28 = 50% completed the survey. Of those responding, 43% accepted permanent employment in the geoscience field (or as commissioned officer if COC), and 43% were accepted into graduate programs.

**Related Action Plans:**

**Improve exit survey**
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geol BS.

For more information, see the Action Plan Details section of this report.

**M 5: Graduate tracking**
The Department will collect data on students career path.

Source of Evidence: Job placement data, esp. for career/tech areas

**Achievement Target:**
75% of graduates will enroll in a graduate or professional program, or begin careers as professional geologists

**Findings (2008-2009) - Achievement Target: Met**
For the 2008-09 year, the survey forms did not distinguish between Geol BA, Geol BS, and Geol BS Majors. Of those responding, 43% accepted permanent employment in the geoscience field (or as commissioned officer if COC), and 43% were accepted into graduate programs.

**O 7: Positive undergraduate experience**
Students will feel valued and challenged by the faculty and fellow students, and develop into advocates for the program

**Related Measures:**

**M 3: Student Exit and Entrance surveys**
The Department will conduct surveys of incoming students and seniors (triggered by 100 hour status), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**
80% of students will complete both surveys

**Findings (2008-2009) - Achievement Target: Partially Met**
For the 2008-09 year, the survey forms did not distinguish between Geol
BA, Geol BS, and Geol BS Majors. For all students graduating during the year, 14/28 = 50% completed the survey. Responses: the program:
a) prepared student for future career: strongly agree 22%, agree 64%,
not sure 14%. b) was a positive professional experience: strongly agree 57%, agree 43%. c) was a positive personal experience: strongly agree 57%, agree 36%, not sure 7%

Related Action Plans:
Improve exit survey
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

For more information, see the Action Plan Details section of this report.

Details for Action Plans Established This Cycle

Improve exit survey
We will increase the % of students who fill out the exit survey by contacting each graduating student individually and urge them to complete the survey. In addition, we will clearly distinguish on the forms the three different undergraduate degree programs: Geol BA, Geol BS, and Geop BS.

Priority: High
Target Date: 09/2009
We will begin the process during Fall 2009

Review capstone exam
Faculty who provided questions for the capstone exam will review the questions in light of the results to verify that questions are relevant and valid.

Priority: High
Target Date: 09/2009
We will begin the process during Fall 2009

Analysis Answers

For Student Learning Outcomes: Based on the assessment findings, what changes will be made to enhance student learning?

The results from this cycle are limited by the relatively low response to the exit survey and poor performance on the capstone exam. Until we obtain a better response to the survey, and review the content of the capstone exam, any possible changes to student learning cannot be evaluated. Enhancements to student learning will have to wait until the end of the next cycle.
For Program Outcomes: What changes will be made to the program as a result of your assessment of other program outcomes?

Not Applicable

Assessment Process: Reflecting on the program’s assessment process, what changes do you intend to make to the assessment plan?

1) a) increase the % of graduating seniors who participate in the exit survey. b) revise exit survey form to distinguish between Geol BA, Geol BS, and Geop BS majors. 2) review the content of the capstone exam.

Annual Reports

Program Contributions

During this cycle, the results for graduating seniors in the Geol BA, Geol BS, and Geop BA were not separated. However, the overall results for the combined group show generally high satisfaction with the programs, both professionally and personally. A large proportion of the graduates (86%) report in the exit survey that they have obtained employment as professional geoscientists or have entered graduate programs. The proportion of our upper-level Geol BS majors involved in research and directed studies (37%) far exceeded our expectations.
Appendix C. Graduate Program

C.1. Course Descriptions
Course Descriptions
Department of Geology and Geophysics
Geology
(GEOL)

609. Field Geology. Credit 1 to 6.
Individual instruction in advanced and specialized field methods, geologic interpretation and field evaluation procedures. Choice of topics and locations of field studies will vary depending upon individual and specific needs. Prerequisite: GEOL 300 or approval of instructor.*

610. Field Methods in Hydrogeology. (1-6). Credit 3.
Field methods in hydrogeology; including ground water drilling technology and law; investigation and planning of well sites; installation of ground water wells; field testing of aquifer properties and analysis of field data. Field trips may be required for which departmental fees may be assessed to cover costs. Prerequisite: GEOL 410 or approval of instructor.

612. Structural Geology. (3-0). Credit 3.
Mechanical principles important to structural geology and experimental results relating to rock deformation followed by applications to natural deformation; mechanisms, rather than geometries. Primarily for students not concentrating in structural geology but who desire an advanced general course. Prerequisite: Approval of instructor.

Properties of reservoir rocks; origin, migration and accumulation of petroleum; geologic interpretation of borehole logs and fluid-pressure measurements and the role of hydrostatic and hydrodynamic pressures in oil accumulation. Prerequisite: Approval of instructor.

621. Contaminant Hydrogeology. (3-0). Credit 3.
Physical concepts of mass transport; dispersion; diffusion; advection; geochemical processes including surface reaction; hydrolysis; biodegradation; aspects of modeling; process and parameter; and remediation. Prerequisite: GEOL 410 or approval of instructor.

622. Stratigraphy. (3-0). Credit 3.
Principles for correlating and naming stratigraphic units; controls on stratigraphic development (sediment supply, base-level change, subsidence, climate, and compaction); principles and application of sequence stratigraphy; subsurface stratigraphy; facies analysis and stratigraphic architecture. Prerequisite: Graduate classification or approval of instructor.

Principles of carbonate sedimentology; carbonate depositional sequences defined in modern environments and utilized to interpret the rock record; introduction to depositional and diagenetic microfacies; shelves, ramps and isolated platforms and their tectonosedimentary significance; suggested for geoscience majors. Prerequisites: A basic understanding of sedimentology and the associated terminology; graduate classification.

624. Carbonate Reservoirs. (3-0). Credit 3.
Recognition and description of hydrocarbon reservoirs in carbonate rocks; classification of carbonate porosity; capillary pressure curves and pore types; pore characteristics as proxies for permeability in reservoir modeling; techniques for mapping flow units. Prerequisites: Graduate classification and approval of instructor.
Concept of groundwater flow and contaminant transport; numerical simulations of solving flow and transport equations; finite difference and finite element methods; software structures of groundwater flow, contaminant transport, density-dependent fluid flow and hydrocarbon remediations; real case applications of software including geological, physical, chemical, biological and hydrological information. Prerequisite: GEOL 410 or approval of instructor.

629. Regional Geology of North America. (3-0). Credit 3.
Regional geology of North America, examining the accumulation and deformation of the rock units involved; structural form and style emphasized; entire geologic history investigated. Prerequisite: Graduate classification or approval of instructor.

Active surface processes as they influence engineering construction; erosion, rivers and floods, slope processes, subsidence, coastal processes, ice, weathering and ground water. Prerequisites: Graduate classification in engineering or geosciences; GEOG 331 or approval of instructor.

635. Engineering Geology. (3-0). Credit 3.
Geological principles applied to the investigation design, construction and maintenance of engineering projects; history, development and role of engineering geologic practice as applied to dams, waste disposal, surface and ground water, tunneling, quarrying and construction materials.

641. Environmental Geochemistry. (3-0). Credit 3.
Geochemical processes affecting the fate and transport of inorganic and organic pollutants in terrestrial systems; equilibrium and kinetic modeling. Prerequisite: GEOL 451 or approval of instructor.

Digital imaging and qualitative and quantitative chemical analysis of geological and material science samples using the electron microprobe; emphasis on quantitative chemical analysis using WDS (wavelength-dispersive spectrometry) methods; use the electron microprobe and correctly interpret analytical results. Prerequisite: Approval of instructor.

645. Geochronology. (3-0). Credit 3.
Earth’s 4.5 billion-year history is divided into units of geologic time based on the observed changes in the rock record: the timing of those changes is quantified by numerical dating methods: this course examines both dating methods and physical and biological changes observed in the rock record. Prerequisite: Graduate classification or approval of instructor.

Fundamental concepts and research techniques in the study of coupled biogeochemical cycles; focus on connections between major elemental cycles of carbon oxygen, hydrogen, nitrogen, sulfur, phosphorus, and metals including biotic and abiotic transformations in subsurface systems. Prerequisite: Graduate classification.

Stable isotopes of oxygen, carbon, sulfur and hydrogen applied to problems in paleontology and paleoecology, carbonate diagenesis, petroleum exploration, and igneous and metamorphic petrology; isotopic paleotemperatures; analytical methods; theory of isotopic fractionation. Prerequisite: GEOL 451 or approval of instructor.
Interrelationships of organisms and environment in the fossil record; methods and criteria available for interpreting ancient environments; critical review of classical studies and current research in paleoecology. Prerequisite: Approval of instructor.

654. Evolutionary Patterns and Theory. (3-0). Credit 3.
Evolutionary patterns in the fossil record and application of evolutionary theory to understanding these patterns; comparisons of neo-Darwinian and punctuational hypotheses; events and processes pertaining to microevolutionary and macroevolutionary change; and methods of determine phylogenies of organisms. Prerequisite: Graduate classification in geological or biological sciences.

History and cause of global change in the earth system, Archean to Holocene; Impact of biotic change on the earth system; influence of tectonics on paleochemistry and climate change; influence of climate on tectonics; methods and models for evaluating global change. Prerequisite: Graduate classification.

663. Fracture and Faulting of Rocks. (3-0). Credit 3.
The structure of fractures and faults in the Earth’s crust at the macroscopic and microscopic scale; formation and evolution of faults, faults networks and fault zones; fault-related rocks and faulting mechanisms; influence of faults on fluid flow properties; seismic faulting and creep; current problems and research opportunities. Prerequisite: Graduate classification.

664. Mechanical Analysis in Geology. (3-0). Credit 3.
Mechanical analysis of geological problems based on concepts of stress, strain, strength, elasticity, viscosity and plasticity; folding, faulting, dike formation, hydraulic fracturing, magma and glacial flow, and cooling of magmatic bodies. Prerequisites: MATH 253; approval of instructor.

Mechanisms of rock deformation from single crystal to mountain range; techniques for mapping stresses and strains and for inferring physical conditions and mechanical behavior at time of deformation; laboratory assignments on descriptive techniques include petrographic microscope-universal stage methods, field procedures and data analysis. Prerequisite: Approval of instructor.

667. Structural Geology II. (3-0). Credit 3.
Application of theoretical and experimental results to problems in natural rock deformation; structural mechanisms on the phenomenological, laboratory and natural scales with emphasis on the genesis of structural features in layered rocks. Prerequisites: GEOL 665, GEOP 611, 615.

Detailed analyses of clastic sedimentary rocks: relationships of facies and depositional environments with emphasis on continental, coastal and shallow shelf clastic sediments; petrography and diagenesis of modern and ancient clastic sediments. Prerequisites: Optical mineralogy course and sedimentology (undergraduate); graduate classification.

Reports and discussions of current research and selected topics from geologic literature. Prerequisite: Graduate classification.
685. Directed Studies. Credit 1 or more each semester.
Enables graduate students to undertake limited investigations not within their thesis or dissertation research and not covered in established curricula. Prerequisites: Graduate classification and approval of instructor.

689. Special Topics in... Credit 1 to 4.
Selected topics in an identified area of geology. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester.
Original research on problems in various phases of geology. Research for thesis or dissertation.
* Field trips required for which departmental fee may be assessed to cover costs.

Geophysics
(GEOP)

611. Geomechanics. (3-0). Credit 3.
Development of continuum mechanics and its application to rock deformation; stress, strain, stress equilibrium, constitutive relations; governing equations for elastic solids and viscous fluids formulated and used to solve elementary boundary-value problems which have application to structural geology and solid-state geophysics. Prerequisite: MATH 221 or equivalent.

615. Experimental Rock Deformation. (3-3). Credit 4.
Results of laboratory testing of mechanical properties of rocks at high pressure and temperature; interaction of theoretical, experimental, petrofabric and field studies of rock deformations as applied to problems in structural geology, seismology and engineering; philosophy of experimentation, apparatus design, data interpretation and extrapolation. Prerequisite: GEOP 611 or GEOL 665 or approval of instructor.

620. Geophysical Inverse Theory. (3-0). Credit 3.
Inferences about Earth structure from geophysical data; explicit treatment of sparse and noisy observations; construction of smooth Earth models; linear inversion of marine magnetic anomalies from seafloor magnetization; smooth inversion of DC sounding data from electrical structure; seismic tomography and geodetic fault-plane reconstructions; advanced methods for nonlinear deterministic inversion. Prerequisite: Graduate classification.

Sampling (wavefield sampling); F-K analysis (applications to dip filtering and migration); deconvolution (deterministic and predicative); velocity estimation and tomography (travel time inversion); imaging in time and depth (migration); Zoeppritz equations and AVO analysis. Prerequisite: GEOP 421 or approval of instructor.

Tectonic classification of basins; tectonic mechanisms responsible for basin formation: mechanical behavior of the lithosphere; subsidence; geophysical signatures of sedimentary basins; tectonic controls on sedimentation and basin filling; petroleum systems and basin-scale hydrologic systems. Prerequisite: Approval of instructor.

629. Seismic Interpretation. (3-3). Credit 4.
Introduces students to the problem of converting seismic properties of reflection time, velocity,
impedance, amplitude and phase to geologic parameters of lithology, structures and stratigraphy using both models and real data. Prerequisite: Approval of instructor.

**630. Interactive Seismic Interpretation. (0-3). Credit 1.**
Introduces students to computerized interpretation used in modern exploration and reservoir studies. Prerequisite: GEOP 629 or concurrent enrollment or approval of instructor.

**651. Theoretical Seismology. (3-0). Credit 3.**
Wave propagation in unbounded and bounded elastic media; seismic reciprocity and the elastodynamic representation theorem; radiation patterns from earthquake sources; body waves, Rayleigh waves, Stoneley waves, Love waves and Lamb waves; characteristic equation for surface waves in a layered half-space; dispersion and phase and group velocities; methods of stationary phase and steepest descents; Cagniard-deHoop technique; ray theory in an inhomogeneous earth; inversion of travel times; viscoelastic wave propagation; normal modes of vibration of the earth. Prerequisite: GEOP 652 or approval of the instructor. (Offered in alternate years.)

**652. Earthquake Seismology. (3-0). Credit 3.**
Seismometry and earthquake precursors; mathematical theory of elasticity and its application to earthquake studies; dissipation of elastic energy; seismic sources; earthquake risk; free modes of the earth; discrimination between underground nuclear explosions and earthquakes. Prerequisite: GEOP 421 or approval of instructor.

**655. Borehole Acoustic. (3-0). Credit 3.**
Introduces propagation of acoustic waves in boreholes, with applications to petroleum exploration and comparisons to other waveguide phenomena in the earth sciences; survey of full waveform acoustic logging and influence of borehole modes for crosswell and vertical seismic profile experiments; exercised in data analysis with industry software. Prerequisite: GEOP 421 or 652 or approval of instructor.

**660. Physics of the Earth’s Interior. (2-3). Credit 3.**
Structure, composition and physical state of the Earth’s interior; constraints on models of the Earth imposed by seismic, gravity, heat flow, and electrical conductivity; thermodynamics and high pressure mineral physics; Earth’s motion and deformation; rheology. Prerequisite: graduate classification.

**666. Principles of Geodynamics. (4-0). Credit 4.**
Geological and geophysical methods and phenomena pertinent to geodynamics; plate tectonics; seismicity and seismology; magnetics; gravity; heat flow; igneous, metamorphic and sedimentary petrology; paleontology; and rock mechanics. Prerequisite: Approval of instructor.

**681. Seminar. (1-0). Credit 1.**
Discussion of subjects of current importance. Prerequisite: Graduate classification.

**685. Directed Studies. Credit 1 to 6 each semester.**
For graduate students to undertake limited investigations not within their thesis or dissertation research and not covered in established curricula. Prerequisites: Graduate classification and approval of department head.

**689. Special Topics in... Credit 1 to 4.**
Selected topics in an identified area of geophysics. May be repeated for credit. Prerequisites: Graduate classification and approval of instructor.

**691. Research. Credit 1 or more each semester.** Research toward thesis or dissertation.
C.2. Current Graduate Students
Adesokan, H., (Ph.D. Student, Geophysics) *Topics in Carbonate Rock Physics and Advanced Seismic Inversion.*
Advisor: Sun, Y.

Arten, Sinem (M.S. Student, Geology). *Organic Biomarkers of Black Shales.*
Advisor: Herbert, B.E.

Arrigoni, V. (M.S. Student) *Origin and Evolution of the Chukchi Borderland.*
Advisor: Ikelle, L.T.

Arjwech, R. (PhD Student, Geophysics) *Resistivity Imaging of Unknown Bridge Foundations.*
Advisor: M.E. Everett

Al-Ghamdi, N., (PhD Student, Geology) *Sequence stratigraphy and chemostratigraphy of Lower Cretaceous Carbonates, Saudi Arabia*
Advisor: Pope, M.C.

Banerjee, Sikhar (M.S. Student, Geology) *Palynology, Particulate Organic Carbon, and Wind-blow Dust in the Hushpuckney Shale, (Pennsylvania, Kansas).*
Advisor: Raymond, A.

Barley, Brent (Ph.D. candidate, Geology). *Titanite U-Pb Ages as a Tracer of Timing and Conditions of Terrane Accretion in the Southern Appalachian Orogen.*
Advisor: Miller, B.V.

Basu, R. (Ph.D. Student, Geophysics) *Time-lapse Analysis of Field data from the Gulf of Mexico.*
Advisor: Gibson, R.

Berna Altinsoy, (M.S. Student, Geology), Texas A&M University
Advisor: Wade, B.S

Brunk, T.J. (M.S. Student, Geology), Texas A&M University
Advisor: John Rick Giardino

Cai, J., (Ph.D. Student, Geophysics) *Topics in Biogeophysics.*
Advisor: Sun, Y.

Cai, R., (M.S. Student, Geophysics) *Topics in Wavelet Transform and High-resolution Spectral Decomposition for Reservoir Fluid Detection.*
Advisor: Sun, Y.

Casey, M., (M.S. Student, Geology) *Topics in Quantitative Seismic Interpretation and AVO analysis.*
Advisor: Sun, Y.

Cavdar, Sevgi (M.S., Geology), Texas A&M University
Advisor: Zhan, H.
Chapman, Shay (M.S. Student, Geology) *Thermokinematic Evolution of the Idaho-Wyoming-Utah Thrust Belt: Dating the Interior of a Thin-skinned Fold and Thrust Belt*
Advisor: D.V. Witschko

Chen, B. (M.S. Student, Geophysics) *Wavefront Construction in Strongly Heterogeneous, Anisotropic Media*
Advisor: Gibson, R.

Choens, R.C. (M.S. Student, Geophysics) *Characterizing Damage Evolution and Yield in Sandstone Under Triaxial Loading as a Function of Changing Effective*
Advisor: Chester, F.M.

Coble, C. (M.S. Student, Geology) *Frictional Strength and Deformation Mechanisms within the Creeping Segment of the San Andreas Fault.*
Co-Advisors: Chester, J.S. and F.M. Chester

Chhoporo, Anealia (Ph.D. Student, Geology), Texas A&M University
Advisor: John Rick Giardino

Dadi, Sireesh (M.S. Student, Geology) *Is the Water Table a Material Free Boundary?*
Advisors: Zhan, H., and D. Sparks

DeLeon, Tiffany-Early (M.S., Geology) *Groundwater Flow to a Radial Collector Well: Test of Different Well Configurations.*
Advisor: Zhan, H.

Dickey, R., (PhD Student, Geology) *Palynology of the Paleocene-Eocene Boundary Interval, Bastrop County, Texas.*
Advisor: T.E. Yancey

Dilci, G. (M.S. Student, Geology) *Effects of Varying Precursory Isotropic Loadings and Non-standard Triaxial Compressions on the Compactive Behavior of Equal-dimensional Loose Sand Samples.*
Advisor: Chester, F.M.

Dou, Q., (Ph.D. Student, Geology) *Topics in Rock-Physics-Based Carbonate Reservoir Characterization.*
Advisor: Sun, Y.

Elsbury, K. (M.S. Student, Geology) *Study of Geological Controls on Rock Erosion at Bridges.*
Advisor: Mathewson, C.

Fall, L.M. (PhD Student, Geology) *Response of Fossil Brachiopod Communities to Eustatically Driven Environmental Change (Bell Canyon Formation, Middle Permian, West Texas).*
Advisor: Olszewski, T.D.
Flake, Ryan (M.S. Student, Geology) General topic: *Carboniferous Paleoceanography and Paleoclimate*  
Advisors: Grossman, E.L. and T. E. Yancey

Foster, Jamie (M.S. Student, Geology) *Lead Uptake by Plants: an Isotopic Study.*  
Advisors: Herbert, B.E. and F. Marcantonio.

Gao, K. (Ph.D. Student, Geophysics) Texas A&M University  
Advisor: Gibson, R.

Advisor: Ikelle, L.T.

Ge, J. (Ph.D. Student, Geophysics) Texas A&M University  
Advisor: Gibson, R.

Gong, Jian (PhD Student, Geology and Geophysics) *Morphogenesis of Photosynthetic Microbial Mats: Experimental and Modeling Results with Application to Fossil Mats of the 3.42 Ga Buck Reef Chert.*  
Advisor: Tice, M.M.

Gowan, J. (M.S. Student, Geophysics) *Seismic Refraction Tomography at the Brazos K/T Boundary Site.*  
Advisor: M.E. Everett

Greenidge, J.C. (M.S. Student, Geophysics) *Seismic Attribute Analysis using Higher Order Statistics.*  
Advisor: Ikelle, L.T.

Gunderson, S. (M.S. Student, Geology) *Sequence Stratigraphy and Detrital Zircon Geochronology of the Middle-Late Ordovician Bromide Sandstone, Oklahoma*  
Advisor: Pope, M.C.

Haney, S. (M.S. Student, Geology) *Study of Weathering Characteristics of Precambrian Granite in the Llano Basin to Assess Engineering Properties*  
Advisor: Mathewson, C.

Harper, R. (M.S. Student, Geology) *Assessment of the Applicability of GIS for Engineering Geologic Applications*  
Advisor: Mathewson, C.

Advisor: Herbert, B.E.

Heo, Joonghyeok (Ph.D. Student, Geology) Texas A&M University  
Advisor: John Rick Giardino
Heron, B. (M.S. Student, Geology) *Estimating Energy Dissipation by Off-fault Fracture and Friction During Seismic Rupture from Study of Core Samples Recovered at the San Andreas Fault Observatory at Depth (SAFOD)*.
Advisor: Chester, J.S.

Hickey, M. (PhD Student, Geophysics) *3-D Controlled-source Electromagnetic Inversion for Near-surface Characterization*.
Advisor: M.E. Everett

Hilding-Kronforst, S. (Ph.D. Student, Geology) Texas A&M University
Advisor: Wade, B.S

Holyoke, C. III (Postdoctoral Fellow, Geology and Geophysics) *Shear-induced Fabric and Weakening of Olivine and Dependence on Pressure and Water*.
Advisor: Kronenberg, A.K.

Hsiung, Shih-Yi (M.S. Student, Geology) *Terrestrial Palynology of Allison Guyot, (Cretaceous)*.
Advisor: Raymond, A.

Hull, T. (M.S. Student, Geology) *Topics in High-resolution Seismic Interpretation and Reservoir Quality Prediction*.
Advisor: Sun, Y.

Advisor: Herbert, B.E.

Johnson, H. (M.S. Student, Geology) *Kinematic Evolution of the Interior Ouachita Orogen Based on Thermochronology*.
Advisor: D.V. Wiltschko

Johnston, Julie (PhD Student, Geology) *Geoscience Education*.
Advisor: Herbert, B.E.

Jolley, C. (M.S. Student, Geology) *Chemostratigraphy of the Blume Member of the Snaky Canyon (Pennsylvanian) Formation, Beaverhead Mountains, Idaho*.
Advisor: Pope, M.C.

Kai Tao (Ph.D. Student, Geology) *Neogene Low-latitude Sea-surface Temperatures from Molluscan Stable Isotopic and Trace Elemental Records*.
Advisor: Grossman, E.L

Kang, Jingqian (PhD Student, Geophysics) Texas A&M University
Advisor: Duan, B.
Krisha, Tracy (M.S. Student, Geology) M.S. Student
Advisor: J.T. McGuire

Co-Advisors: Chester, J.S. and F.M. Chester

Kolkmeier, B. (M.S. Student, Geology) Study of Geological Risks to Visitors at Canyon Lake Gorge
Advisor: Mathewson, C.

Lee, A.L. (M.S. Student, Geology) Texas A&M University
Advisor: John Rick Giardino

Li, Y. (M.S. Student, Geology) Seismic and Sequence Stratigraphy of Pennsylvanian Rocks, Central Midland Basin
Advisor: Pope, M.C.

Liu, Z. (M.S. Student, Geophysics) Traveltime Time Exploration using Modified Paraxial Traveltime Corrections
Advisor: Gibson, R.

Liu, Zaifeng (PhD Student, Geophysics) Texas A&M University
Advisor: Duan, B.

Ma, N. (M.S. Student) Seismic Imaging of Receiver Ghosts of Primaries.
Advisor: Ikelle, L.T.

Mammadova, E. (M.S. Student, Geophysics) Influence of Carbonate Rock Types on CO$_2$ Sequestration.
Advisor: Sun, Y.

McClenning, Bree (M.S. Student, Geology) Pb Isotopic Study of Fens in the San Juan Mountains of Southwestern Colorado
Advisor: Rick Giardino
Co-advisor: Franco Marcantonio

McClure, Roberta (M.S. Student, Geology) Remediation of Mining Wastes.
Advisor: Herbert, B.E.

Mieles, John (M.S. Student, Geology) Three-dimensional Solute Transport in a Permeable Reactive Barrier (PRB)-Aquifer System.
Advisor: Zhan, H.

Miller, Clint (PhD Student, Geology) Texas A&M University
Advisor: Herbert, B.E.
Mohamed, Ahmed (PhD Student, Geology) *Dynamics of Water Table in Unconfined Aquifer Flow.*
Advisors: Zhan, H., and D. Sparks

Moore, J.R. (D.B. Harris Postdoctoral Research Fellow, Geology and Geophysics) *Quantifying the Taphonomic Biases affecting Terrestrial Vertebrate Fossil Assemblages.*
Advisor: Olszewski, T.D.

Advisor: Tice, M.M.

Moustafa, M. (PhD Student, Geology) *Sequence Stratigraphy and Chemostratigraphy of Triassic-Jurassic Carbonates, Jifarah Basin, Northwestern Libya.*
Advisor: Pope, M.C.

Mukherjee, S. (PhD Student, Geophysics) *3-D Finite Element Analysis of Controlled-source Electromagnetic Induction in Ferromagnetic Bodies.*
Advisor: M.E. Everett

Mullen, K. (M.S. Student, Geology) *Transition from Peridotite-mylonite to Serpentine-rich Fault Rocks along a Strike-slip Fault System, Twin Sisters Ultramafic Massif, Washington, USA.*
Advisor: Newman, J.

Advisors: Tice, M.M. and H. Mills (Oceanography)

Palomo, Amanda (M.S. Student, Geology) Texas A&M University
Advisor: Tice, M.M.

Advisor: D.V. Wiltschko

Pochivalov, O.G. (PhD Student, Geophysics) *Description of Isoscalar Giant Dipole Resonance in Nuclei.*
Advisor: Ikelle, L.T.

Prakash Khedun (Ph.D. Student, Geology) Texas A&M University
Advisor: John Rick Giardino

Priest, J. (Ph.D. Student, Geophysics) *Anisotropy Near a Salt Dome Using the Radon Transform with Generalized Travel Time*
Advisor: Gibson, R.
Ray-Blakely, Charita (PhD Student, Education and Human Resources) Motivation as a Factor Guiding Graduate Student Engagement in Teaching and Learning Professional Development.
Co-Advisor: Herbert, B.E.

Redman, C.M. (PhD Student, Geology) Macroeology and Biogeography of Mesozoic Terrestrial Vertebrate Communities.
Advisor: Olszewski, T.D.

Regmi, N.R. (Ph.D. Student, Geology) Texas A&M University
Advisor: John Rick Giardino

Rodosovich, D.K. (M.S. Student, Geology) Texas A&M University
Advisor: John Rick Giardino

Advisor: Newman, J.

Sills, D. (M.S. Student, Geology) Shape Preferred Orientations of Porphyroclasts at the San Andreas Fault Observatory at Depth (SAFOD): Evidence for Aseismic Creep
Advisor: Chester, J.S.

Steen, Sean (M.S. Student, Geology) Why is the Appalachian Fold and Thrust Belt Different from all Others: the Role of Paleoclimate on Structural Style.
Advisor: D.V. Wiltshko

Singh, Ajay (PhD Student, Geology) $^{230}$Th Dynamics in the Eastern Equatorial Pacific Ocean: Testing the $^{230}$Th-normalization Method to Estimate Sediment Fluxes.
Advisor: Franco Marcantonio

Advisor: Sun, Y.

Song, Q. (Ph.D. Student, Geology) Topics in Quantifying Reservoir Permeability Heterogeneity.
Advisor: Sun, Y.

Advisor: Mathewson, C.

Strauss, Josiah (Ph.D. Student, Geology) Stable Isotopes of Mollusk Shells and Foraminifera as Proxies for River Discharge and Hypoxia on the Texas Shelf
Advisor: Grossman, E.L.
Vuong, A. (Ph.D. Student, Geophysics) Texas A&M University
Advisor: Gibson, R.

Wehner, Matthew (M.S. Student, Geology) Texas A&M University
Advisor: Weiss, R.

Wells, R. (M.S. Student, Geology) *Rheologic Evolution during Thrusting within Carbonate Fault Rocks.*
Advisor: Newman, J.

Weymer, Bradley (M.S. Student, Geology) Texas A&M University
Advisor: Weiss, R.

Workman, B., (M.S. Student, Geology) *Sequence Stratigraphy and Detrital Zircon Geochronology of the Middle-Late Ordovician Eureka Quartzite, Southern Nevada*
Advisor: Pope, M.C.

Wulf, T., (M.S. Student, Geology) *Sequence Stratigraphy and Detrital Zircon Geochronology of the Middle-Late Ordovician Eureka Quartzite, Southern Idaho*
Advisor: Pope, M.C.

Xie, Ruifang (PhD Student, Geology) *Glacial-Interglacial Changes in the Position of the ITCZ in the Eastern Equatorial Pacific: Using Radiogenic Isotopes as Dust Provenance Tracers.*
Advisor: Franco Marcantonio

Xiujun, Y. (PhD Student, Geophysics) *Simulation of Seismic Real and Virtual Data in 3D.*
Advisor: Ikelle, L.T.

Yeatman, R., (M.S. Student, Geology) *Sequence Stratigraphy and Surface to Subsurface Correlation of Silurian Fusselman Formation, West Texas*
Advisor: Pope, M.C.

You, Kehua (PhD Student, Geophysics) *Vapor Flow and Transport in Fractured Media*
Advisor: Zhan, H.

Zhang, T., (Ph.D. Student, Geophysics) *Topics in Carbonate Rock Physics, Advanced Seismic Inversion, and Quantitative Seismic Interpretation.*
Advisor: Sun, Y.

Zhang, Z., (M.S. Student, Geophysics) *Topics in S-Transform and High-resolution Spectral Decomposition for Reservoir Fluid Detection.*
Advisor: Sun, Y.

Zhong, Jinquan (Postdoctoral Fellow, Geology and Geophysics) *Damage Rheology and its Effect on Rupture Dynamics and Near-field Ground Motion.*
Advisor: Duan, B.
Zhu, D. (Ph.D. Student, Geophysics) Texas A&M University
Advisor: Gibson, R.

Zhuang, Kelin (Ph.D. Student, Geology) Texas A&M University
Advisor: John Rick Giardino
C.3. Theses and Dissertations
Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: BP

Advisor: Chester, F.M.

Advisors: B.J. Willis
Current Position or Placement upon Graduation: Unknown

Thesis, Advisor: M.E. Everett
Placement on Graduation: Boise State University.

Advisor: Zhan, H.
Current Position: Geologist, British Petroleum

Advisor: Sager, William W. and Hopper, J.R
Current position or placement upon graduation: Office of Naval Research, Slidell, MS.

Gao, G. (2009) *Modeling of Solute and Water Transport in Heterogeneous Porous Media and Study On Scale-Dependent Dispersion*, 130pp, PhD Dissertation, China Agriculture University, August
Advisors: Feng, S., and H. Zhan
Current Position: Staff Scientist, China Academy of Science.

Advisor: J.T. McGuire
Current Position or Placement upon Graduation: Conoco Philips, Houston, TX

Advisor: J.T. McGuire
Current Position or Placement upon Graduation: Marathon


Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: Korea Gas Corporation


Advisors: Sun, Y.
Current Position or Placement upon Graduation: Saudi Aramco, Saudi Arabia.


Advisors: B. Herbert
Current Position or Placement upon Graduation: post-doctoral research associate, Pacific Northwest National Lab, Marine Science Laboratory.


Advisor: Zhan, H.
Current Position or Placement upon Graduation: Unknown


Advisors: A.H. Bouma
Current Position or Placement upon Graduation: Unknown


Advisor: D.V. Wiltschko
Placement on Graduation: BP America, Houston

Miller, Heather (ABD) *Transferring Research on Complex Earth Systems to the Classroom: Supporting Novices’ Model-Based Reasoning through Design and Pedagogy*, M.S. Thesis, Texas A&M University

Advisor: B. Herbert
Current position: Assistant Professor, Grand Valley State University, Michigan.


Advisors: Hopper, J.R.
Current Position or Placement upon Graduation: Unknown
Riene, Vera (2009) *Characterization of Roabiba Sandstones Reservoir in Bintuni Field, Papua, Indonesia*  
Advisors: W. Ahr  
Current Position or Placement upon Graduation: Exxon Indonesia

Sanchez Flores, Maria del Rosario (2009) *Planning for Water Scarcity: The Vulnerability of the Laguna Region, Mexico*  
158p. Hydrological Science Program, Texas A&M University  
Advisors: John Rick Giardino  
Current Position or Placement upon Graduation: Assist. Prof University of Monterrey Tech, Mexico

Advisor: M.E. Everett  
Placement on Graduation: Lawrence Berkeley National Laboratory.

2008

Advisors: Hopper, J.R.  
Current Position or Placement upon Graduation: Unknown

Advisor: D.V. Wiltschko  
Placement on Graduation: BP America, Houston

Advisor: M.E. Everett  
Placement on Graduation: Marathon Oil Co. (Houston TX)

Advisors: Hopper, J.R.  
Current Position or Placement upon Graduation: Unknown

M.S. Thesis, 51 pp., Texas A&M University, December.  
Advisor: Chester, F.M.  

Advisors: W. Ahr
Current Position or Placement upon Graduation: Devon Energy


Advisors: Hajash, A. and Sasson, R.
Current Position or Placement upon Graduation: Unknown


Advisor: J.T. McGuire
Current Position or Placement upon Graduation: Asst. Professor, Cal State Fullerton


Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: Unknown


Advisors: John Rick Giardino
Current Position or Placement upon Graduation: Project Specialist, Texas Water Resources Institute


Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: ExxonMobil


Advisor: M.E. Everett
Placement on Graduation: Chiang Mai University (Thailand).

2007


Advisor: Chester, J.S.

Baez-Cazull, Susan (2007) *Spatial and Temporal Controls on Biogeochemical Indicators at the Small-Scale Interface Between a Contaminated Aquifer and Wetland Surface Water*, Ph.D. Dissertation,
Texas A&M University, December.
Advisor: J.T. McGuire
Current Position or Placement upon Graduation: Water Remediation Technology, LLC Wheat Ridge, CO.

Advisor: M.E. Everett
Placement on Graduation: Geosystem (Milan, Italy).

Advisor: Zhan, H.

Advisor: Mathewson, C.
Current Position or Placement upon Graduation: Unknown

Advisors: Everett, M.E and Hopper, J.R.
Placement on Graduation: Marathon Oil Co. (Houston TX)

Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: Conoco-Phillips

Advisor: R.L. Carlson
Current Position or Placement upon Graduation: Unknown

Advisor: Zhan, H.

Advisor: Raymond, A.

Current Position or Placement upon Graduation: Teaching Certification Program, U. New Hampshire


Advisors: Richard L. Gibson, Jr.

Current Position or Placement upon Graduation: Seismic MicroTechnology


Advisors: B. Herbert

Current Position or Placement upon Graduation: U.S. Nuclear Regulatory Agency.


Advisor: Raymond, A.

Current Position or Placement upon Graduation: Chevron, Houston Tx.


Advisors: B. Herbert

Current Position or Placement upon Graduation: Assistant Professor, Mississippi State.


Advisor: Corapcioglu, Y. and H. Zhan

Current Position: Hydrogeologist, JD2 Environmental Inc., Pennsylvania, USA


Advisor: D.V. Wiltshko

Current Position or Placement upon Graduation: Conoco/Phillips, Midland


Advisors: Hopper, J.R

Current Position or Placement upon Graduation: Unknown

Advisors: Spang, J.H.
Current Position or Placement upon Graduation: Hess Corporation (Houston)


Advisor: Raymond, A.
Current Position or Placement upon Graduation: Ph.D. Student, Utah State University


Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: Ion Geophysical (GXT)

2006


Advisor: Sager, William W.
Current position or placement upon graduation: British Petroleum in Houston, TX


Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: deceased


Advisor: T.D. Olszewski
Current Position: Encana Corporation, Denver, CO


Advisors: Ikelle, L.T.
Current Position or Placement upon Graduation: Tel Aviv University


Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: Exxon London


Advisor: Grossman, E.L.
Current Position or Placement upon Graduation: Marathon Oil

Advisors: Miller, D.J. and R.N. Guillemette
Current Position or Placement upon Graduation: Core Laboratories, Houston, TX


Advisors: John Rick Giardino
Current Position or Placement upon Graduation: Production Geologist, Shell Oil


Advisor: Chester, F.M.
Current Position: Hess Corporation


Advisor: M.E. Everett
Placement on Graduation: Marathon Oil Co. (Houston TX)


Advisor: T.D. Olszewski
Current Position: Rosetta Resources Co., Houston, TX


Advisors: John Rick Giardino
Current Position or Placement upon Graduation: Research Scientist, University of California, Riverside


Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: XTO Energy, Fort Worth


Advisors: B.J. Willis
Current Position or Placement upon Graduation:

Advisor: Mathewson, C.
Current Position or Placement upon Graduation: Unknown

2005


Advisors: W. Ahr
Current Position or Placement upon Graduation: Anadarko


Advisor: Mathewson, C.
Current Position or Placement upon Graduation: Unknown


Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: Anadarko


Advisor: Mathewson, C.
Current Position or Placement upon Graduation: Unknown


Advisors: B.J. Willis
Current Position or Placement upon Graduation: Unknown


Advisor: Chester, F.M.
Placement upon Graduation: Shell


Advisors: Newman, J. and A.K. Kronenberg
Current Position or Placement upon Graduation: Chesapeake Energy, Oklahoma City, OK


Advisor: Sager, William W.
Current position or placement upon graduation: Returned to the Ecuadorian Navy (INOCAR)

Advisors: John Rick Giardino
Current Position or Placement upon Graduation: Senior Scientist, National Remote Sensing Authority of Egypt


Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: Encana


Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: Somewhere in Turkey.


Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: BP


Advisor: M.E. Everett
Placement on Graduation: Schlumberger (Houston TX)

Olusola, Magbabeola (2005) Sequence Stratigraphy of Niger Delta, Robertkiri Field, Onshore Nigeria”. 103 pages Texas A&M University, December

Advisors: B.J. Willis
Current Position or Placement upon Graduation: Unknown


Advisors: B. Herbert
Current Position or Placement upon Graduation: Continued on with his PhD at TAMU.


Advisor: Chester, J.S.
Placement upon Graduation: Conoco-Phillips, then Shell

Advisor: Sager, William W.
Current position or placement upon graduation: Went to work at C&C Technologies in Houston, TX.


Advisors: B. Herbert
Current Position or Placement upon Graduation: Environmental consulting.


Advisors: B.J. Willis
Current Position or Placement upon Graduation:


Advisor: Chester, J.S.
Current Position: Conoco-Phillips


Advisors: Ikelle, L.T.
Current Position or Placement upon Graduation: WesternGeco, Houston, TX


Advisor: Zhan, H.
Current Position: Tenured-track Assistant Professor at University of Houston-Clear Lake.

2004


Advisors: Ikelle, L.T.
Current Position or Placement upon Graduation: Devon Energy, Houston, TX


Advisors: Grossman, E.L. and J.W. Morse
Current Position or Placement upon Graduation: Dominion Exploration and Production

Advisors: B.J. Willis
Current Position or Placement upon Graduation: Unknown

Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: Shell

Advisor: D.V. Wiltschko
Current Position or Placement upon Graduation: Unknown

Advisor: M.E. Everett
Placement on Graduation: Shell Oil Co. (Houston TX)

Advisors: Kronenberg, A.K. and W. Lamb
Current Position or Placement upon Graduation: BP America, Houston, TX

Advisor: D.V. Wiltschko
Current Position or Placement upon Graduation: Unknown

Advisors: B. Herbert
Current Position or Placement upon Graduation: Pursuing a PhD at the U. of Tennessee.

Advisor: M.E. Everett
Placement on Graduation: environmental consultant, NH

Advisors: W. Ahr
Current Position or Placement upon Graduation: Petro-Consulting firm, London

University, December.
Advisors: B. Herbert
Current Position or Placement upon Graduation: Environmental consulting.

Advisors: W. Ahr
Current Position or Placement upon Graduation: Unknown

Advisor: Chester, F.M.

Advisors: B.J. Willis
Current Position or Placement upon Graduation: Unknown

Advisor: M.E. Everett
Placement on Graduation: The Louis Berger Group (Morristown NJ)

Advisor: M.E. Everett
Placement on Graduation: Assistant Professor, University of Louisiana at Lafayette.

Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: Hellenic Petroleum

2003

Advisor: Slowey/Carlson.
Current Position or Placement upon Graduation: Unknown

Advisor: Mathewson, C.
Current Position or Placement upon Graduation: Unknown
Current position or placement upon graduation: Went to work for Monterey Bay National Marine Sanctuary.

Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: Shell

Advisor: Sager, William W.
Current position or placement upon graduation: Returned to her hometown of Leominster, MA.

Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: BP Aberdeen

Advisor: Dorobek, S.L.
Current Position or Placement upon Graduation: Unknown

Current position or placement upon graduation: Went to work for NOAA in Silver Springs, MD.

Advisors: B.J. Willis
Current Position or Placement upon Graduation: Unknown

Advisor: Chester, F.M.

Current position or placement upon graduation: Found employment in Olympia, WA.

Advisor: Mathewson, C. 
Current Position or Placement upon Graduation: Unknown

Advisor: Ahr, Wayne M 
Current Position or Placement upon Graduation: Petro-Consulting firm, Houston

Advisor: Raymond, A. 
Current Position or Placement upon Graduation: IODP

Advisor: Ahr, Wayne M 
Current Position or Placement upon Graduation: Pertamina

Advisor: Chester, J.S. 

Advisor: Johnson, B. 
Current Position or Placement upon Graduation: Marathon Oil, Houston TX

2002

Advisors: W. Ahr 
Current Position or Placement upon Graduation: Qatar National Petroleum

Advisor: Mathewson, C. 
Current Position or Placement upon Graduation: Unknown

Advisor: Chester, F.M.
Current Position: Turkish Petroleum Company


Advisors: Richard L. Gibson, Jr.
Current Position or Placement upon Graduation: CGGVeritas


Advisors: B.J. Willis
Current Position or Placement upon Graduation: Unknown


Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: Chesapeake Energy


Advisors: Miller, J. and Hajash, A.
Current Position or Placement upon Graduation: Unknown


Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: Unknown


Advisor: Ahr, Wayne M
Current Position or Placement upon Graduation: Hess Oil


Advisor: Chester, F.M.
Current Position: Unocal Corporation, then Marathon.

Advisor: D.V. Wiltschko
Current Position or Placement upon Graduation: Marathon Oil, Houston

    Advisor: Chester, J.S.

    Advisor: D.V. Wiltschko
    Current Position or Placement upon Graduation: Consultant

    Advisor: Zhan, H.
    Current Position: Tenured Associate Professor at Kyungpook National University, South Korea.

    Advisors: Richard L. Gibson, Jr.
    Current Position or Placement upon Graduation: Intevep

    Advisors: Lamb, W. and Popp R.K.
    Current Position or Placement upon Graduation: Unknown

    Advisor: M.E. Everett
    Placement on Graduation: Texas A&M University

    Advisor: Ahr, Wayne M
    Current Position or Placement upon Graduation: Total

    Advisor: Johnson, B.
    Current Position or Placement upon Graduation: ExxonMobil, Houston TX

Advisor: Mathewson, C.  
Current Position or Placement upon Graduation: Unknown

Advisors: B. Herbert  
Current Position or Placement upon Graduation: Assistant Professor, U. of Southern Mississippi.

Advisors: Richard L. Gibson, Jr.  
Current Position or Placement upon Graduation: Total Exploration

Advisor: Rabinowitz, P.D.  
Current Position or Placement upon Graduation: Unknown
C.4. External Examiners at Other Institutions
2009


  External Examiner: Chester, J.S.


  Served as co-advisor: H. Zhan.


  Advisors: Aharonov, E., (Hebrew University of Jerusalem), Sparks, D. W.

Goodyear, Stephen (2009) Ph.D. candidate committee member, University of Texas at Austin

  Advisor: Wade, B.S.


  External Examiner: Hajash, A.

Li, J. (2009) *Vapor Flow and Transport in Unsaturated zone*. PhD Student, China Agriculture University

  Advisors: Zhan, H., and G. Huang


  Advisors: Aharonov, E., (Hebrew University of Jerusalem), Sparks, D. W.


  External Examiner: B.S. Wade


  Served as co-advisor: H. Zhan


  Advisors: Huang, G., and H. Zhan

2008


  External Examiner: M.E. Everett

External Examiner: B.V. Miller.

Heim, N.A. (2008) *The Spatial Structure of Biodiversity in The Fossil Record: Contrasting Global, Continental and Regional Responses to Climate Change*. PhD, University of Georgia, Athens

External Examiner: T. D. Olszewski


Advisors: Qian, J., and H. Zhan


Served as co-advisor: H. Zhan


Served as co-advisor: H. Zhan

2007


Served as external examiner: H. Zhan.


External Examiner: Hopper, J.R.


Served as external examiner: H. Zhan.


External Examiner: B.V. Miller.

External Examiner: M.E. Everett

External Examiner: B.V. Miller.

### 2006

External Examiner: Pope, M.C.

External Examiner: Pope, M.C.

External Examiner: B.V. Miller.

Advisor: Franco Marcantonio
Current position: working for Environmental Consulting firm in New Jersey

Advisor: Franco Marcantonio
Current position: currently PhD candidate at Columbia (graduating Dec 2009)

External Examiner: Chester, F.M.

Oldenborger, G. (2006) *Advances in Electrical Resistivity Tomography: Modeling, Electrode Position Errors, Time-Lapse Monitoring of an Injection/Withdrawal Experiment, and Solution Appraisal*, PhD Dissertation, Boise State University, (NOTE: This was the first ever PhD awarded at Boise State University in any discipline.)
External Examiner: M.E. Everett

Advisor: Franco Marcantonio
Current position: after completing post-doc at University of Chicago, Ali accepted an assistant professorship at the University of Miami (RSMAS)

2004


External Examiner: B.V. Miller.


External Examiner: B.V. Miller.

2003


External Examiner: Pope, M.C.


External Examiner: Pope, M.C.


External Examiner: B.V. Miller.


Served as co-advisor: H. Zhan


External Examiner: B.V. Miller.
2002


External Examiner: B.V. Miller.


External Examiner: B.V. Miller.


External Examiner: B.V. Miller.
C.5. Student Papers & Articles
In Press Student Authors

Hassler, L. (MS Geology student) Advisor: Wiltschko, D.V.

McNeal (Sell), K.S. (PhD student) Advisor: B. Herbert

Miller, H.R. Advisor: B. Herbert

2009 Student Authors

Benavides, A. (Ph.D Geophysics student) Advisor: M.E. Everett

Chen, Z. (Ph.D Geology, Hefei University of Technology) Advisors: Qian, J., and H. Zhan.

Cutlip, P. (M.S. Geology student) Project Advisor: Raymond, A.

Dor, Ory (Ph.D. Student at USC, Advisor: Y. BenZion, now postdoc at Brown)

Dou, Q. (Ph.D. Geology student) Advisor: Sun, Y.

Gao, G. (Ph.D Hydrological Engineering, China Agricultural University) Advisors: Feng, S., and H. Zhan.

Harvey, O. (Ph.D student) Advisor: B. Herbert

Hutto, A. P. (Undergraduate student) Advisors: Yancey, T.E. and B.V. Miller

Intaraprasong, T. (Ph.D Geology student) Advisor: Zhan, H.

Lai, H.-L. (Ph.D Geophysics student) Advisor: Gibson, R.

Lambert, G.R. (M.S, Geology student) Advisor: Wiltschko, D.V.

Markley, C.T. (Ph.D student) Advisor: B. Herbert

McCarty, R. (M.S. Geology student) Project Advisor: Raymond, A.

Nair, S. (Ph.D student) Committee member: B. Herbert

Park, E. (Ph.D Geology student) Advisor: Zhan, H.

Sassen, D. S. (Ph.D Geophysics student) Advisor: M.E. Everett

Slone, E. D. J. (M.S. Geology student) Project Advisor: Raymond, A.

Song, Q. (Ph.D. Geology student) Advisor(s): Sun, Y.

Sun, D. (Ph.D Geology student) Advisor: Zhan, H.

Tominaga, M. (Ph.D student) Advisor: Sager, William W

Addressing Sulfate Induced Heave in Lime Treated Soils

Dallas N. Little, P.E., F.ASCE1; Syam Nair2; and Bruce Herbert2

Abstract: Civil engineers are at times required to stabilize sulfate-bearing clay soils with calcium-based stabilizers. Delerterious heaving in these stabilized soils may result over time. This paper addresses critical questions regarding the consequences of treating sulfate laden soils with calcium-based stabilizers. The authors describe the nature (chemistry and structure) of the minerals ettringite/thaumasite blamed for deleterious reactions and explain why these structures may lead to damage. The writers also describe the mechanisms of the mineral growth, and the extent of mineral growth based on the amount of sulfate minerals present in the soil. The writers explain why the rate of ettringite growth is treated soils should not be expected to follow a controlled rate of ettringite development such as that which normally occurs in Portland cement concrete. The writers compare the rate and degree of ettringite development in soils to the classical model of nucleation and growth typical of most crystal structures. Finally, the writers evaluate the role of soil mineralogy in controlling soil behavior at varying sulfate contents and verify the existence of a threshold level of soluble sulfates in soils that can trigger substantial ettringite growth.

DOI: 10.1061/(ASCE)GT.1943-5606.0000185

CE Database subject headings: Volume change; Soil stabilization; Portland cement; Lime; Concrete; Sulfates.

Author keywords: Ettringite; Nucleation; Crystal growth; Volume change; Soil stabilization; Portland cement concrete; Volume change; Threshold sulfate level; Concrete; Sulfates.

Introduction and Scope

The purpose of this paper is to articulate certain confusing issues that engineers encounter when dealing with deleterious sulfate reactions in soils treated with calcium-based stabilizers. A general belief among many practicing engineers, which is based on a general familiarity with the hydration mechanisms of Portland cement concrete, is that ettringite formation in soils is fast and sulfate content in soil is the sole factor dictating the extent of mineral formation. In reality, sulfate content is only one among many factors that contribute to ettringite formation, and the process is not always rapid (Dermaut et al. 2005; Taylor et al. 2001; Little et al. 2008). Uncertainties also exist regarding how much ettringite can form in a stabilized matrix and how much expansion will occur during its formation. The extent of measurable expansion may vary with environmental conditions, rigidity of the cementitious matrix, void content, availability of water, timing of ettringite formation, and rate of crystal growth (Mitchell and Dermaut 2019; Dermaut 1995; Little and Graves 1995; Little et al. 2005; Dermaut et al. 2006a). No rules or guidelines have been established regarding the proportionality between the amount of ettringite formed and the extent of expansion in the stabilized media. Therefore, questions remain as to how much the matrix can expand if the soil cannot accommodate this newly formed ettringite crystals. Neville (2004) addressed similar concerns regarding sulfate reactions in Portland cement concrete.

In this paper the writers:

1. Describe the link between the structure of ettringite and thaumasite and the mechanism of expansion and damage.
2. Discuss the two-phase mechanism for ettringite and/or thaumasite mineral growth in soils treated with calcium-based stabilizers.
3. Calculate the quantity of ettringite that can form based on the amount of soluble sulfates in the soil mass.
4. Identify why expansion causes disruption based on comparison of molar volumes of the components of ettringite and the molar volume of ettringite formed.
5. Assess the threshold levels of soluble sulfates that can trigger ettringite mineral growth which is capable of causing disruption in pavement layers.

Background

Sulfate induced heaving, due to the formation of expansive minerals like ettringite and thaumasite, has been recognized as a problem in Portland cement concrete, stabilized soils, weathered cements, alkaline fly ash, POZ wastes, chromite ore processing residues, and cement based waste solidification products (Sherwood 1961; Mitchell 1986; Hunter 1988; Petr and Little 1992; Dermaut 1995; Myeni et al. 1997; Taqqu et al. 1999; Taylor et al. 2001; Minadeo et al. 2002; Harris et al. 2004; Dermaut et al. 2005; Lee et al. 2005). Experimental studies have shown that soils with varying levels of sulfates, from above 1,000 to 10,000 ppm, may precipitate ettringite when treated with calcium based stabilizers (Hunter 1988; Mitchell and Dermaut 1992; Puppala et al. 2003).
Student's Conceptual Model Development of Coastal Sand Sediment Transport
During Authentic Science Inquiry in an Introductory Physical Geology Course

Heather R. Miller
Texas A&M University, Department of Geology & Geophysics, College Station, TX 77843
hmiller@geo.tamu.edu

Karen S. McNeal
Mississippi State University, Department of Geosciences, Mississippi State, MS 39762
karen.mcneal@msstate.edu

Bruce E. Herbert
Texas A&M University, Department of Geology & Geophysics, College Station, TX 77843
herbert@geo.tamu.edu

Contract Grant Sponsor: NSF; Contract grant number: ESI-0083336
Correspondence to: H.R. Miller; E-mail: hmill@geo.tamu.edu
From Accretion to Collision: Motion and evolution of the Chaochou Fault, Southern Taiwan

David V. Wiltshire\textsuperscript{a,1}, Lauren Hassler\textsuperscript{a}, Jih-Hao Hung\textsuperscript{b}, Ho-Sung Liao\textsuperscript{b}

\textsuperscript{a}Department of Geological Sciences and Center for Tectonophysics, Texas A&M University, College Station, TX 77843-3115

\textsuperscript{b}Department of Earth Sciences, National Central University, Chung-Li, Taiwan 32001

ABSTRACT

The Chaochou Fault (CCF) is an important tectonic boundary of the Taiwan orogenic belt between the metamorphosed Slate Belt to the east and the Western Foothills foreland fold and thrust belt to the west. Although the fault is known to be a high angle oblique sinistral thrust fault in places, both its kinematic history and its current role in the development of the orogen are poorly understood. Field fabric data suggest that hanging wall structural orientations vary along strike, particularly in the on-land extension of the intersection of the Eurasian continent-ocean boundary and the Luzon Arc. Slip lineations also reveal a change in fault motion from dip-parallel in the north to a more variable pattern in the south. This correlates somewhat with recent GPS results that indicate that the direction of current horizontal surface motion changes along strike from nearly perpendicular to the fault in the northern, to oblique and nearly parallel to the fault in the south. Mountain front sinuosity and valley floor width/valley height ratio indicate higher activity and uplift in the north. Geodetic and geomorphic data together indicate that along the northern segment of the CCF the Slate Belt (hanging wall) is currently undergoing rapid uplift related to oblique arc-continent collision between the Eurasian continent and the Luzon.

\textsuperscript{1} Corresponding author: d.wiltshire@tamu.edu
Unexploded ordnance discrimination using time-domain electromagnetic induction and self-organizing maps

Alfonso Benavides I · Mark E. Everett · Carl Pierce Jr.

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Abstract Self-organizing maps (SOM) are implemented for discrimination of geologic noise, buried metal objects and unexploded ordnance using the geophysical method of time-domain electromagnetic induction. The learning and misfit measures are based on a Euclidean metric. The U* matrix method is shown to be a reliable tool for determining data clusters and cluster boundaries. The performance of SOM for data-type discrimination was tested using three synthetic, idealized geophysical datasets consisting of exponential, multi-exponential and stretched-exponential decaying transients. In addition, experimental data were acquired using a modified Geonics EM63 instrument. Results from the synthetic examples show that SOM clusters the data based on their functional origin, when represented using U*-matrices. The percentage of correct classification is 100%. Unsupervised learning using the field dataset obtained with the Geonics EM63 succeeded in producing a multi-clustered map in which the background transients cluster themselves and are separated from clusters associated with metal clutter objects and UXO. Even though in some cases the SOM did not produce a single cluster for each type of causative body, it was able to separate clutter data from target data by producing several small clusters. The results are encouraging in view of the heterogeneity and sparsity of the training dataset.

1 Introduction

Detection of conductive targets such as unexploded ordnance (UXO) at shallow depths is important for remediation of areas subjected to military activities that have been reassigned to civil use (National Research Council 1996). One of the most successful tools is the controlled-source electromagnetic induction (EMI) metal detector which measures the decaying secondary magnetic field caused by the dissipation of eddy currents induced in the target and surrounding geology by a transmitted primary magnetic disturbance. The main drawback of metal detectors is the high rate of false alarms due to an intrinsic sensitivity to small amounts of buried metal typically caused by non-UXO objects (clutter). High false alarm rates dramatically increase the cost of clean-up operations (Butler 2004).

One of the main challenges to improve the effectiveness of metal detectors is to improve signal processing algorithms that discriminate between UXO, clutter and geologic (background) signals. The time-domain EMI method is sensitive to the background response at early times, defined as \( t << \tau \sim \mu L^2 \), where \( \mu \) is magnetic permeability, \( \sigma \) is electrical conductivity, \( L \) is a characteristic length such as the target size or the transmitter-target distance, and time \( t = 0 \) is the instant of the transmitted magnetic disturbance. The amount of background corruption, or geological noise, depends on the electrical conductivity of the host as well as the size, depth and metal content of the target. For small volume targets (UXO or clutter items), the background EMI response dominates the early time response so it is difficult to assess the presence of a target by observing the secondary field decay at different positions above the target along a spatial profile. Also, at late time (i.e. when \( t > \tau \) or equivalently the EMI...
Characterization of Damage in Sandstones along the Mojave Section of the San Andreas Fault: Implications for the Shallow Extent of Damage Generation

ORY DOR,1,5 JUDITH S. CASTER,2 YEHUDA BEN-ZION,1 JAMES N. BRUNE,3 and THOMAS K. ROCKWELL4

Abstract—Following theoretical calculations that suggest shallow generation of rock damage during an earthquake rupture, we measure the degree of fracture damage in young sedimentary rocks from the Juniper Hills Formation (JHF) that were displaced 21 km along the Mojave section of San Andreas Fault (SAF) and were not exhumed significantly during their displacement. In exposures adjacent to the fault, the JHF typically displays original sedimentary fabrics and little evidence of bulk shear strain at the mesoscopic scale. The formation is, however, pervasively fractured at the microscopic scale over a zone that is about a 300 m wide on the southeast side of the SAF near Little Rock. The abundance of open fractures, the poor consolidation, and the shallow inferred burial depth imply that the damage was generated close to the surface of the Earth. The spatial correlation of this damage with a seismically active trace of the SAF suggests that it was generated by SAF slip events that by assumption were of a seismic nature throughout the displacement history of the JHF. Thus the JHF provides a very shallow upper bound for the generation of brittle damage in a seismic fault zone. The fracture fabric is characterized by preferred orientations of fractures that split grains between contact points and is consistent with overall deformation under directed compression. However, the available results cannot be used to distinguish between proposed off-fault damage mechanisms. Fracture orientations are compatible with a maximum compressive stress oriented at a high angle to the fault at about 10 m, and at a lower, more variable angle farther away from the fault. The fracture distribution and fabric are consistent with observations made of the microscale damage characteristics of the Hungry Valley Formation in the northwestern section of the SAF in the Mojave, and with previous observations of exhumed, ancestral strands of the SAF.

Key words: Fault-zone structure, rock damage, San Andreas fault, earthquake rupture mechanism, mode I fractures, Sedimentary rocks.

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Rock-physics-based heterogeneity characterization of a carbonate reservoir in the Permian Basin
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Summary

Pore structure and grain size play an important role in controlling the complexity of velocity-porosity relationships and permeability heterogeneity in carbonate reservoirs, in addition to mineral composition and pore fluid. A frame flexibility factor (γ) has been found to be able to quantify the effect of pore structure changes on acoustic wave velocity and permeability in carbonate reservoir rocks. Our study of a San Andres carbonate reservoir, Permian Basin, shows that for core samples of given porosity, the lower the frame flexibility factor γ, the higher the acoustic wave velocity. A frame flexibility factor γ value of $3.85$ could be used to separate permeability zones of different geological origin for the studied San Andres carbonate reservoir. Samples with frame flexibility factor $γ > 3.85$ are dolostone with vuggy pores or tight dolostone. On the other hand, samples with frame flexibility factor $γ < 3.85$ are dolostone with dolomudstone or dolomudstone with microcrack pores. Using the frame flexibility factor $γ$, different porosity-velocity and porosity-permeability trends can be classified with clear geologic interpretations such as carbonate rock and pore types. New porosity-permeability relations with $γ$ classification help delineate high-permeability zones in the San Andres reservoir, and may be useful for other similar carbonate reservoirs as well.

Introduction

A robust and practical rock physics model is important in understanding the complicated relationships between the acoustic properties and the reservoir parameters for carbonate rocks. The Differential Effective Medium model, Kuster-Tekoiz model, extended Xu-White model and revised Slichter-Castagna model have been used in predicting carbonate reservoir properties. Sun et al. (2003, 2004) introduced a rock physics model by defining elastic parameters called frame flexibility factors. These frame flexibility factors depend less on porosity than wave velocity. They are not only related to pore structure but also to solid-pore connectivity and grain size. This poroelasticity model has been successfully proven at the core-scale by measured core data for its effectiveness in quantifying pore structure (Sun, 2007). These frame flexibility factors have been successfully used for carbonate reservoir permeability inversion from seismic data (Bracco et al., 2005).

In this paper, we use the rock physics model introduced by Sun (2009) to analyze the velocity-porosity complexity and to understand the permeability heterogeneity of a San Andres carbonate reservoir. This progress report is based on analysis of core measurements and well logging data. Results will be used for simultaneous porosity and permeability inversion from seismic data.

Method and Data Sets

Based on an extended Biot theory of poroelasticity, Sun (2000, 2004) derived a simplified rock physics model for carbonate rocks. The formulae to calculate the frame flexibility factors are summarized below:

Let $V_p$, $V_s$, and $γ$ be compressional velocity, shear velocity, and bulk density, respectively. Let $K$ and $μ_0$ be bulk and shear modulus, respectively. We have

\[ γ = 1 + \frac{\log(p)}{\log(1-φ)} \]  \hspace{1cm} (1)

Where

\[ f = \frac{k}{k_s} + (1 - \frac{k_s}{k})F_\gamma \]  \hspace{1cm} (2)

\[ F_\gamma = \frac{1 - φ}{(1 - φ)(1 - \frac{k}{k_s})} \]  \hspace{1cm} (3)

\[ R_s = \frac{k - K}{φ(K_f - K)} \]  \hspace{1cm} (4)

\[ K = \frac{4V_p^2 - V_s^2}{3} \]  \hspace{1cm} (5)

Where $γ$, $f$, and $F_\gamma$ are frame flexibility factors defined by Sun (2000, 2004), $K_s$ and $K_f$ are matrix and fluid bulk moduli. The frame flexibility factor $γ$ is inversely proportional to aspect ratio and grain size. In this study, we
Seismic detection of paleocave system and its influence on carbonate reservoir compartmentalization
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Summary

A complex paleocave system in the San Andres Formation, Permian basin, Texas is characterized through detailed seismic analysis, integrating core, log and seismic data. The reservoir, controlled by karstic, fractured and diagenetically altered systems, is extensively altered by anhydrite in a dominantly karstic system. Controlling carbonate reservoir compartmentalization of the studied field, verified by open-top interpreted maps and petrophysical data. The paleocave system represents karst-controlled collapsed features of different sizes and patterns. In the area of high volume production, the collapsed paleocave system is characterized by irregularly developed crinkle and fracture breccias, mosaic breccias and cave fillings in the upper 100 feet of San Andres Formation. Along the transition from the platform to basin, it is marked by a linear collapse with the occurrences of sags and small vertical faults that are observable in seismic data. The complexity of collapse and cave system can be explained using an analogy to modern hydrological systems. Our method may be useful to interpret occurrence of similar subsurface paleocave systems in other areas.

Introduction

Presence of karst-controlled paleocave systems is one of the major factors causing carbonate reservoir heterogeneity and compartmentalization. If porous and permeable, the paleokarst systems can be important hydrocarbon reservoirs in world class fields. However, the filling sediment and collapse during burial also destroy most of the cavernous porosity. The field studied in this research is located on the eastern Central Basin platform of the Permian basin, west Texas. The carbonate reservoir experienced substantial subsurface exposure during the Guadalupian period. Reservoir production from the field has been problematic due to the fluid barriers caused by tight gypsum and anhydrite-cemented dolostones, as revealed by available cores. The average porosity and permeability of the tight dolostone intervals are usually lower than 2% and 1 MD, respectively. Our analysis indicates that the occurrence of these tight barriers may be the result of a fully developed paleokarst system with vertical and lateral spatial complexity. Detailed knowledge of 3-D distribution of this paleokarst system is very important for optimizing development strategy and improving reservoir recovery.

Spatial variation and complexity of a paleocave system present immense challenges for seismic reservoir characterization. (Wrench, 2005; Martin, 2006; and others). A correct geologic model for the occurrence of a paleocave system is also important for a successful prediction of the 3-D distribution of the system. In this study, we focus on part of the east central flank of the Central Basin platform and develop a method of paleocave system identification by integrating core and log, seismic inversion and 3-D geometric attribute analysis. Using results of this seismic characterization we further explore an island hydrologic model to explain the development of the paleocave system and its control on the reservoir: compartmentalization of the field.

Method

Using available core data in two cored wells, we first identify the karst features and their related collapsed paleocave packages in the San Andres Formation. For the high volume area of the field where both core and log data are available, we interpret the collapse and karst features using well log data calibrated by core description. We then perform model-based seismic impedance inversion to determine the distribution of the collapsed paleocave system. For the transitional zone from the platform to the basin where well logging and core data are not available, geometric seismic attributes, including the coherence and multi-attribute analyses, are calculated to detect the flank of the collapsed paleocave system. Integrating the hydrologic and structure features with the sequence stratigraphy of the San Andres Formation, Permian Basin (Wrench and Kerans, 2004), we recommend a geological model for the mechanism of the development of the collapsed paleocave system for the studied field.

Interpretation and analysis

Core analysis shows that two cored wells drilled through the upper San Andres Formation in the studied area record a pronounced paleokarst event overprint on the fine dolostone and dolomite lithofacies. As shown in Figure 1, the paleokarst collapse features are indicated as crinkle and fracture breccias in core and well and mosaic breccias and cave fillings. Intense cavernous dissolution is suggested by the large clasts of "float" in the bluish anhydrite. Except for small open fractures, the clasts by dissolution are cemented by anhydrite cementation, which accounts for a reduction in the "tight" karst zones in the San Andres Formation.

In the core wells where paleocave packages are identified, well log data are used for the log signatures of the "tight" karst zone. The paleocave zones have anomalously low acoustic and low bulk-density in Figure...
Comparison of alternative models for simulating anomalous solute transport in a large heterogeneous soil column

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SUMMARY

This study compared five different models for evaluating solute transport in a 1250-cm-long, saturated and highly heterogeneous soil column. The five models were: the convection-dispersion equation (CDE), the mobile-immobile model (MIM), the convective lognormal transfer function model (CLT), and the spatial fractional advection-dispersion equation (FADE) and the continuous time random walk model (CTRW). Each of these models was used to fit the breakthrough curves (BTCs) at each distance individually and was also used to fit the BTCs at different distances simultaneously. Dependence of estimated parameters on distance was investigated. The estimated parameters at 200 cm were used to make predictions at subsequent distances. Highly anomalous transport behavior was observed in the column as the BTCs demonstrated significant irregular shape and long tailing. This study indicated that CDE, CLT and FADE were unable to describe the anomalous BTCs adequately and their parameters changed with transport distance significantly. Compared to CDE, CTRW and MIM better captured the evolution of anomalous BTCs. However, MIM did not explain the distinct BTC tailing satisfactorily. In contrast to MIM, CTRW better simulated the long tails of BTCs. The spreading parameter (β) of CTRW was close to one and remained approximately constant at different travel distances. To make the comparison of these five models more general beyond the specific transport condition in the soil column, a generic evaluation of the advantages and disadvantages of these five models was presented in terms of their theory framework and a priori knowledge of the model behaviors.

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Introduction

The fate and transport of solute in soils and groundwater has long been a focus of experimental and theoretical research in subsurface hydrology. An important aspect in understanding the fate of solute is to describe its transport behavior using appropriate models. The convection-dispersion equation (CDE) (Bear, 1972) is the first transport model widely used to describe solute transport in porous media. For laboratory columns packed with macroscopically homogeneous soils, it is generally accepted that solute transport can be well described by CDE. However, in heterogeneous soils the measured breakthrough curves (BTCs) usually demonstrate early arrival and distinct long tailing as a result of the inherent heterogeneity of natural soils at various scales (Berkowitz et al., 2003). These phenomena are referred to as anomalous or non-Fickian transport (Berkowitz et al., 2003), and CDE cannot describe it adequately (Levy and Berkowitz, 2003; Berkowitz et al., 2006). Such anomalous phenomena even can be found during solute transport in repacked homogeneous soil column or sandbox (e.g., Padilla et al., 1999; Levy and Berkowitz, 2003; Bromly and Hinz, 2004; Cortis and Berkowitz, 2004). Another problem of CDE is the well recognized scale-dependent dispersion, i.e., the estimated dispersion coefficient or dispersivity is not constant but rather varies with spatial and/or temporal scales (Gelhar et al., 1992). The problem of increasing dispersion coefficients is related to the lack of a macroscopic representative elementary volume in a heterogeneous field. Even if the field is macroscopically homogeneous, the dispersion coefficient is not a constant from the beginning, but only after the tracer plume has been transported over a large enough domain, containing several correlation lengths (Dentz et al., 2000). Therefore, it is often difficult for CDE with a single set of parameters to predict BTCs at different distances.

Alternative models have been proposed to account for the observed anomalous BTCs. The mobile-immobile model (MIM) presented by van Genuchten and Wierenga (1976) is a practical and physically-based approach to describe anomalous solute transport...
Evaluation of Anomalous Solute Transport in a Large Heterogeneous Soil Column with Mobile-Immobile Model

Guangyao Gao; Shaoyuan Feng; Hongbin Zhan; Guanhua Huang; and Xiaomin Mao

Abstract: This study uses the mobile-immobile model (MIM) and the traditional convection-dispersion equation (CDE) to analyze the observed breakthrough curves (BTCs) at different distances in a 1.229-cm-long saturated and highly heterogeneous soil column. It provides a simple method to determine the mobile water fraction independently as the ratio of effective porosity over total porosity of the packed soil materials. The effective porosity is calculated a priori as the ratio of measured flow rate and estimated pore-water velocity. It is found that there is a significant amount of immobile water in the soil column, resulting in the anomalous early breakthrough and tailing behaviors of the measured BTCs. Comparing to the CDE, the measured asymmetric BTCs at various scales can be better described by the MIM, especially their early arrival and long tailing parts. The degree of anomalous transport behavior in this large heterogeneous soil column is reduced with transport scale due to the increased mobile water fraction and associated greater solute mixing, and the MIM can detect this evolution adequately. The solute mass transfer timescales at various distances are compared to the advection timescales and longitudinal interaction timescales, respectively. It is found that the latter is better correlated with the timescales of solute mass transfer, which implies that the mass transfer rate in the heterogeneous soil column is predominantly subjected to the local velocity variation.

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Introduction

Solute transport in soils and groundwater has long been a focus of experimental and theoretical research by numerous investigators because of environmental concerns. The classical convection-dispersion equation (CDE) is the most commonly used method for describing solute transport in porous media (Bear 1972). The CDE is derived using the mass conservation law of solute and Fick's law and is assumed that convective solute transport occurs in all parts of the soil pore space. It is generally accepted that good results can be obtained with the CDE to simulate solute transport processes in homogeneous soils. However, the CDE is less satisfactory to describe anomalous or nonequilibrium transport phenomena characterized by asymmetric breakthrough curves (BTCs) demonstrating early breakthrough and distinct tailing, which have frequently been observed during solute transport in heterogeneous soils (van Genuchten and Wierenga 1976; Bond and Wierenga 1980; Li et al. 2004; Levy and Barkowitz 2003). Such phenomena also occur during miscible displacement experiments in so-called packed homogeneous soil columns (Padilla et al. 1999; Bormly and Hinz 2004). Another problem of using the CDE to simulate transport processes is the scale-dependent dispersion, i.e., the dispersion coefficient or dispersivity is not constant but depends on the spatial and temporal scales, which was found both in field and laboratory scale transport (Geihr et al. 1992).

The conceptual mobile-immobile model (MIM) presented by van Genuchten and Wierenga (1976) is a practical and physically based approach to describe the anomalous solute transport behavior in heterogeneous soils. The asymmetry observed in the BTCs for a conservative solute is often attributed to physical nonequilibrium within the soil, resulting from the presence of immobile or stagnant water in pore space (Smettem 1984; Griffioen et al. 1998; Haggerty et al. 2004). The MIM model assumes that the heterogeneous liquid regime in soil pore space can be separated into mobile (flowing) and immobile (static) liquid regions with solute transfer between these two regions, accounting for the early arrival and long time tailing of solute transport (van Genuchten and Wierenga 1976; Toride et al. 1999). The MIM model has been used to successfully describe solute transport in both saturated and unsaturated soils including aggregated soils (van Genuchten and Wierenga 1977; Nked-Nkiza et al. 1983), undisturbed field soil cores (Smettem 1984), heterogeneous soils with local stratification (Herr et al. 1999), as well as layered soils (Li et al. 1994). As discussed by Griffioen et al. (1998), a major attribute of the MIM model is that it characterizes the influence of the soil's heterogeneous structure on the transport process and describes the asymmetry observed in BTCs using simple mathematical forms.

Despite the versatile and popular use of the MIM model in analyzing asymmetric solute BTCs obtained from laboratory
A New Spectrophotometric Method for Rapid Semiquantitative Determination of Soil Organic Carbon

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Physical, chemical, and biological processes occurring in soils are greatly influenced by SOC content. Estimates of SOC are often required for a wide variety of agricultural, environmental, and engineering applications. Both quantitative and semiquantitative methods are available for SOC determination (Schumacher, 2002). Although quantitative methods for SOC are more accurate than semiquantitative methods, they are also typically more expensive and time consuming (Abella and Zimmer, 2007), making them impractical for applications requiring rapid analysis of a large number of samples. For such applications and applications where spatial variability in SOC is more critical than measurement accuracy, semiquantitative methods provide an attractive alternative to quantitative methods. In addition to being faster and cheaper, semiquantitative methods for SOC determination often have the added advantage of being easily adapted for in-field use.

A number of semiquantitative methods are available for laboratory and in-field estimation of SOC. These include soil color measurements (Fernandez et al., 1988), loss-on-ignition (Konen et al., 2002), remote sensing (Chen et al., 2005), and nondestructive or destructive spectroscopic techniques (McCarty et al., 2002; Bowman et al., 1991). Selecting an appropriate semiquantitative SOC method can be challenging because each method has different advantages and disadvantages. Semiquantitative methods vary in measurement accuracy, degree of site specificity, applicability for large-scale use, and environmental friendliness.
Provenance of Paleocene-Eocene Wilcox Group Sediments in Texas: the Evidence from Detrital Zircons

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EXTENDED ABSTRACT

The late Paleocene and early Eocene (38 Ma – 52 Ma) Wilcox Group, a major stratigraphic unit of the Paleogene in the northwestern Gulf of Mexico geologic province, was deposited in response to tectonic uplift and erosion in the continental interior. Sediment was transported to the continental margin and deposited in a large clastic wedge in central and eastern Texas called the Rockdale delta system that was fed by the Mt. Pleasant fluvial channel system (Fisher and McGowen, 1968). The Wilcox Group (and overlying Carrizo Formation, a unit often included within the Wilcox Group) is a major producer of oil and gas in the subsurface of the Gulf of Mexico and contains large lignite coal reserves in the upper coastal plain area (Kaiser et al., 1986). Recent discovery of large amounts of oil and gas contained in Paleocene-Eocene sands in deep waters of the northern Gulf of Mexico (Meyer et al., 2005) has stimulated interest in further documentation of the depositional history of Wilcox Group strata as a means of determining the source and pathway of sediment transport into deep water environments. The possibility of major drawdown of water within the Gulf of Mexico due to basin isolation (Berman and Rosenfeld, 2007; Rosenfeld and Fudell, 2003) and the presence of Wilcox age large submarine canyons (Galloway, 2007; McDonnell et al., 2008) adds additional complexity to the reconstruction of depositional controls and patterns for Wilcox Group deposits. Sediments of the Wilcox Group were also deposited during an interval of time spanning the PETM (Paleocene-Eocene Thermal Maximum), a time of rapid global temperature rise. Temperatures abruptly increased as much as six degrees Celsius, as determined by stable isotope determinations of organic remains and soil precipitates (John et al., 2008; Storey et al., 2007). The PETM is recognized primarily by an associated carbon and oxygen isotope excursion and is dated as lasting 105 thousand years with a recovery phase lasting 126 thousand years (Ginsberti et al., 2007). In the Gulf Coast region this interval lies within the Platyctena abundance zone (Elisik and Crabaugh, 2001) and corresponds with the Apectolinium flood zone (Crouch et al., 2001).

There are longstanding unanswered questions about the source areas, or provenance, of the sediments that compose the Wilcox Group. Traditional interpretations cited western Laramide age uplifts as a major source of Wilcox sediments, a view still held by many workers. Doubt about the importance of Laramide uplifts in providing a major source of sediment to the Wilcox Group in the Texas sector of the Gulf province was raised in publications describing the petrography of Paleogene sands (Todd and Folk, 1957; Harris, 1962; McCauley, 1981). These publications reported a dominance of minerals (both heavy and light fractions) and clasts indicative of metamorphic terranes and only small amounts of materials indicative of volcanic sources. Based on these data, the early Paleogene sediments were interpreted to be derived from
A general framework of stream–aquifer interaction caused by variable stream stages
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SUMMARY
Stream–aquifer interaction is a critical zone where surface water and groundwater exchange mass, energy, and chemicals. Previous analytical studies of stream–aquifer interaction consider stream stage fluctuations that are steady functions of time. This study improves those solutions by simultaneously considering temporally and spatially variable stream stages, low-permeability streambeds, and pumping wells near the stream. Semi-analytical solutions of drawdown and stream–aquifer flow rate in the Laplace–Fourier domain are provided and used to obtain solutions in the real time–space domain after the inverse Laplace–Fourier transform, where the stream–aquifer flow rate refers to the rate of discharge between a stream and an adjacent aquifer. The stream–aquifer flow rate caused by the temporally variable stream stage is found to decline with time and becomes negligible when time is sufficiently long. A closed-form analytical solution for the stream–aquifer flow rate caused by a diffuse-type flood wave is obtained, and it can be used to predict the response of an aquifer upon a passing flood wave. For a diffuse-type flood wave that dies out in about 24 h, we find that the stream–aquifer flow rate drops nearly exponentially with time and dies out at about 13.4 h for a sandy aquifer and an alluvial streambed. Sensitivity analysis shows that the stream–aquifer flow rate increases with the diffusion coefficient of the flood wave (\( \alpha \)) which controls the width and amplitude of the wave, and decreases with the average flood wave velocity (\( v_0 \)). Low-permeability streambeds increase stream–aquifer flow rate and also delay the response to the stream stage fluctuations. For a time-dependent stream stage function with a period of 30 days, the maximal stream–aquifer flow rate with a 0.5 m thick low-permeability streambed is 34% less than that obtained without the streambed.

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Introduction
Hydrologists have been fascinated with stream–aquifer interaction research for many decades for a number of reasons. Stream–aquifer interaction is a critical zone where surface water and groundwater exchange mass, energy, and chemicals. For instance, base flow from an aquifer to the adjacent stream plays an important role for maintaining sustainable stream flow, particularly during the dry seasons. Groundwater withdrawal wells have often been placed near streams to obtain high quality and plentiful water, a process that will result in stream depletion, which is the reduction in groundwater discharge to the stream as attributable to pumping. A key issue related to stream depletion is to calculate the stream–aquifer flow rate, which is the rate of discharge between a stream and an adjacent aquifer. A positive stream–aquifer flow rate refers to a losing stream whereas a negative one refers to a gaining stream. Understanding the dynamics of stream–aquifer interaction is one of the most important research topics for hydrologists. At present, studies of stream–aquifer interaction associated with this investigation can be summarized into two types: type-A and type-B. The type-A studies focus on investigating the stream–aquifer flow rate caused by pumping wells, assuming that the stream stage does not change. The type-A studies focus on investigating the aquifer response to stream stage fluctuations without involving any pumping wells. The type-A studies are briefly reviewed first. Thelis (1941) and Jenkins (1968, 1970) presented analytical solutions of the stream–aquifer flow rate for fully penetrating streams without streambeds, caused by nearby pumping wells with constant pumping rates. The highly simplified models of Thelis (1941) and Jenkins (1968, 1970) were later improved by many investigators including Ronbaugh (1963), Hantush (1965), Wallace et al. (1969), Hantush (1968), Chen and Wei (2001), Zlotnik and Huang (1996), Butler et al. (2001), Kirk and Herbert (2002), Sun and Zhan (2007), and Yeh et al. (2008). Among these investigations, Hantush’s work (1965) was notable for its inclusion of semi-permeable streambeds adjacent to the stream. Hunt (1999) tried to improve Hantush’s model (1965) and provided analytical solutions of the stream–aquifer flow rate by considering a narrow and shallow stream. However, as pointed out by Sun and Zhan (2007), the Hunt’s model (1999) was mathematically identical to that of Hantush’s (1965), provided that the horizontal flow assumption was invoked. To address the issue of partial penetration of the stream, one has to...
Quasi-shear wave ray tracing by wavefront construction in 3-D, anisotropic media

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ABSTRACT

Wavefront construction (WFC) methods provide robust tools for computing ray theoretical traveltimes and amplitudes for multi-valued wavefields. They simulate a wavefront propagating through a model using a mesh that is refined adaptively to ensure accuracy at rapid change during propagation. However, an implementation for quasi-shear (qS) waves in anisotropic media can be difficult, since the two qS slowness surfaces and wavefronts often intersect at shear-singularities. This complicates the task of creating the initial wavefront mesh, as a particular wavefront will be the faster qS-wave in some directions, but slower in others. Analogous problems arise during interpolation as the wavefront propagates, when an existing mesh cell that crosses a singularity on the wavefront is subdivided. Particle motion vectors provide the key information for correctly generating and interpolating wavefront meshes, as they will normally change slowly along a wavefront. Our implementation tests particle motion vectors to ensure correct initialization and propagation of the mesh for the chosen wave type and confirms that the vector changes gradually along the wavefront. With this approach, the method provides a robust and efficient algorithm for modeling shear-wave propagation in a 3-D, anisotropic medium. We have successfully tested the qS-wave WFC in transversely isotropic models that include line singularities and kite singularities. Results from a 3-D model with a strong vertical gradient in velocity also show the accuracy of the implementation. In addition, we demonstrate that the WFC method can model a wavefront with a triple junction caused by intrinsic anisotropy and that in multi-valued traveltimes are mapped accurately. Finally, qS-wave synthetic seismograms are validated against an independent, full-waveform solution.

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1. Introduction

An accurate knowledge of velocity anisotropy can be very important for interpreting and processing seismic data. For example, Levin (1978), Alkhoshah and Tsvankin (1995), Grechka and Tsvankin (1998), and Grechka et al. (2001) described methods for estimating the moveout velocities in transversely isotropic (TI) media, which can be difficult to estimate from surface seismic data. Bank (1984) and Winterstein (1986) showed that neglecting anisotropy can easily lead to substantial midpoints of layer thicknesses when analyzing seismic data. Leslie and Lawton (1999), Grechka et al. (2002), and Hornby et al. (2003) showed that corrections for shale anisotropy are necessary to obtain accurate subsurface seismic images.

Shear (S) wave anisotropy can be even more difficult to treat in data processing and interpretation than P-wave anisotropy. Levin (1978, 1979, 1980) pointed out that quasi-S (qS) waves usually do not have hyperbolic traveltime curves and that moveout velocity varies with distance. Winterstein (1985) concluded that layer thickness estimates obtained from S-wave data can be significantly thicker than those from P-wave data in the presence of anisotropy, and the percentage of clay in layers dominates the magnitude of anisotropy. Processing to measure shear-wave splitting also provides further information on the properties of the layers that cannot be obtained from qS-wave data. For example, shear-wave splitting measured from vertical seismic profiles can be interpreted in terms of crack-induced anisotropy (Crampin, 1985; Shearer and Chapman, 1989; Douma and Crampin, 1980; Horne et al., 1979; Crampin and Chatwin, 2003; Nistola and McMechan, 2005). Such information regarding crack properties from qS-wave splitting can provide important insights for understanding reservoir performance (Ramos-Martinez et al., 2000).

Efficient and accurate numerical modeling to support processing of qS-propagation phenomena can be more difficult than for P-wave data. In particular, S-wave propagation in anisotropic media is complicated by the S-wave singularities, where the two qS-wave slowness surfaces cross (Crampin, 1985; Shearer and Chapman, 1989; Chapman and Shearer, 1998; Coates and Chapman, 1998; Vavrycuk, 2001). There are three main types of S-wave...
Arsenic Risk Assessment: The Importance of Speciation in Different Hydrologic Systems

C. T. Markley • B. E. Herbert

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Abstract The processes impacting arsenic toxicity are a function of molecular speciation, where risk from chronic exposure to the reduced arsenic species is estimated to be four orders of magnitude higher than many oxidized arsenic species. While the adverse health effects of arsenic are generally well known, the impact of speciation on carcinogenic and noncarcinogenic adverse health effects has rarely, if ever, been considered in traditional chronic arsenic exposure risk assessments. Utilizing standard Environmental Protection Agency protocol, lifetime cancer risk and hazard quotient are calculated for chronic arsenic exposure at the local, regional, and national scale to characterize potential risk as a function of arsenic speciation. Additionally, the antagonistic and synergistic impacts of biogeochemical processes on arsenic bioavailability and bioaccessibility are discussed and show chronic exposure risk is likely to be reduced below some maximum value calculated for reduced arsenic species.

Keywords Arsenic Speciation • Risk assessment

1 Introduction

The adverse health effects of arsenic are well known, where chronic exposure can impact the respiratory, gastrointestinal, cardiovascular, nervous, and hematopoietic systems (Jain and Ali 2000). Chronic arsenic exposure is manifested in conditions such as skin lesions, carcinoma, keratosis, and blackfoot disease (Mandal et al. 1998). Further, the Environmental Protection Agency (EPA) categorizes arsenic as a Class A human carcinogen. Arsenic speciation greatly impacts the processes that result in arsenic toxicity. The oxidized species, arsenate (As(V)), is a molecular analog of phosphate and can inhibit oxidative phosphorylation (Gremland and Stoltz 2003). The reduced species, arsenite (As(III)), is considered a more toxic arsenic species because of its ability to bind with sulphydryl groups, thereby impacting the function of a broad range of proteins and enzymes (National Research Council 1999). Pertussive organoarsenicals are generally considered the least toxic arsenic species and include monomethylarsonic acid (MMA(\text{V})) and dimethylarsinic acid (DMA\text{III}), and numerous higher molecular weight organoarsenicals (Jain and Ali 2000);
Modeling Phosphate Influence on Arsenate Reduction Kinetics by a Freshwater Cyanobacterium

Christopher T. Markley · Bruce E. Herbert

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Abstract Arsenic speciation in natural surface-water systems can be highly impacted through biological processes that result in non-thermodynamically predicted species to dominate the system. In laboratory experiments, arsenate reduction by a freshwater cyanobacterium exhibited saturation kinetics increasingly inhibited by elevating solution phosphate concentrations. Approximately 100% arsenate reduction occurred by days 4, 7, and 10 in the low (0.35 μM), middle (3.5 μM), and high (35 μM) phosphate treatments, respectively, with maximum arsenate reduction rates ranged from 0.013 μmol As g C−1 day−1 in the high-phosphate treatment to 0.398 μmol As g C−1 day−1 in the low-phosphate treatment. Saturation kinetic models were utilized to evaluate the impact of cell growth and arsenate-phosphate uptake competition on arsenate reduction rates by the cyanobacterium. Results showed reduced arsenicals dominate arsenic speciation once growth reached steady state, indicating reduced arsenicals may dominate natural systems, even when considering conservatively high, abiotic arsenic oxidation.

Keywords Arsenic · Phytoplankton · Biotransformation · Kinetics

1 Introduction

Arsenic fate and transport in surface waters, as determined by chemical speciation, is often influenced by phytoplankton-mediated reactions. Early evidence was presented by Andréa [3] studying marine environments who observed a strong correlation between photosynthetic activity and the concentration of methylated arsenicals, which suggested phytoplankton methylate arsenic. Both marine and freshwater algae have subsequently been shown to uptake, reduce, and methylate inorganic arsenic species before excretion re-introduces reduced arsenicals back to surface-water environments [10, 13, 15]. A variety of more complex organoarsenicals has been identified including arsenobetaine, arsenurogen, and arsenurothiosides in phytoplankton cell extracts [4, 29]. Arsenate reduction and methylation rates in freshwater environments are often dependent on the dynamics of phytoplankton blooms, which are affected by nutrient enrichment and seasonal variables such as light and temperature. Solrín et al. [25] described seasonal variations of arsenic speciation in Lake Biwa, Japan, where the proportion of arsenite increased in spring and fall and dimethylarsonic acid (DMA) proportions increased in summer. The increased arsenite proportions correlated to the log growth phase of two separate phytoplankton blooms where PO4− was not a limiting nutrient, and concurrent uptake of phosphate and arsenate was rapid. However, upon reaching the stationary bloom phase, when growth is often nutrient-limited, other forms of reduced arsenic species accumulated. Under these conditions, uptake and metabolism are slow, allowing further detoxification of A5+ through reduction and methylation to DMA [11].

Microbial diversity allows for a multitude of potential beneficial and detrimental interactions with arsenic in surface-water systems. Arsenate can be used as a respiratory oxidant by dissimilatory arsenate reducing procaryotes, while energy created through arsenate oxidation can be used to fix CO2 by chemolithoautotrophic arsenic oxidizers [31]. However, many microbe-mediated arsenic biotransformations occur as detoxification mechanisms, such as arsenite oxidation by heterotrophic arsenite-oxidizing
The Relationship Between Instructors’ Conceptions of Geoscience Learning and Classroom Practice at a Research University

C.T. Markley, H. Miller, T. Kneeshaw, B.E. Herbert

ABSTRACT
Reform of undergraduate science education will need to be supported with effective professional development for current and future faculty. The professional development programs will need to address the knowledge, skills, and beliefs of higher education faculty so that they can implement the kind of effective practices that result in the intended learning and meets the needs of diverse learners. To support the design of these programs, this research characterized the relationships between faculty’s conceptions of teaching and learning on their teaching practices. Teaching faculty at a Doctoral/Research University were randomly interviewed to assess conceptions with respect to: 1) individual faculty learning, 2) student learning based on academic level, 3) how teaching is valued by the organization and 4) course goals. Additionally, classroom observations were conducted to determine the level of student-teacher interaction and cognitive engagement among students with graphical and symbolic representations, as well as other manipulatives. Observations indicated teacher-centered classes across all academic levels. These data contrasted the subject’s conceptions that cognitive and technical skill development is best achieved through self-directed learning. Analysis of the interviews and observations suggested the contradiction between learning practices the subject viewed as effective and the utilized teaching methods resulted from two major barriers: 1) the instructors’ conceptions on the evolution of student learning and 2) an institutional reward structure that doesn’t support the development of effective teaching practices.

INTRODUCTION
It is generally assumed that post-secondary science classes are conducted using the lecture format, even though these methods are known to promote memorization in students, and not true understanding of the material. The focus of this study is two-fold: to quantify the prevalence of lecture based courses in a Doctoral/Research University through classroom observations and to understand how the instructors’ conceptions of learning influence the teaching practices observed in the classroom. Reform of undergraduate science courses involves a number of critical issues including faculty teaching expertise and the overly specialized research training of PhD and post-doctoral students. This can leave both current and future faculty poorly prepared to teach effectively (Gappa et al., 2007; Goldie and Done, 2001). Improving instructor knowledge and skills to teach effectively can be supported, in part, through effective professional development programs. The goals of professional development programs should be based upon the knowledge and skills required for effective teaching, as well as an understanding of the typical values, beliefs and misconceptions about teaching and learning held by graduate students, post-docs, and faculty.

Effective teaching is the practice that results in the intended learning, and meets the needs of diverse learners most of the time. Effective teaching requires a diverse set of knowledge including a research-based understanding of learning: the nature of diverse student knowledge; the design of learning environments that align learning objectives, assessments, and instructional activities; and how to progressively refine courses based on reflection and feedback. Likewise, effective teaching also requires instructors have the skills to use this knowledge to design and implement effective learning environments. The values and beliefs of instructors can also impact their practice. Self-efficacy refers to an instructor’s belief in their capability to impact student learning and perform the tasks associated with their academic position (Kagan, 1992a,b). Research on K-12 teachers indicates how teachers’ conceptions that greater self-efficacy has been associated with changes in teaching practices (Smylie, 1989), use of new curricula (Fool et al., 1989) and increased student achievement in reading and math (Ashton and Webb, 1986).

The actual teaching practices employed by instructors have a major influence on how students learn (Trigwell and Shale, 2004). Unfortunately, there is often a misalignment between instructor conceptualization of the learning outcomes derived from their teaching and the actual teaching practice in the classroom. Previous surveys showed that higher education faculty generally believe their teaching is student-centered and effective in facilitating student learning, though classroom observations indicate that the dominant teaching practice in use is a teacher-centered, didactic lecture format focused on information transfer (Murray and Macdonald, 1997; Norton et al., 2005). Lecturer-centered teaching practices that often dominate post-secondary science courses tend to promote rote memorization and poor student motivation (Trigwell et al., 1990; Trigwell et al., 1998). Teaching for conceptual understanding, on the other hand, is best achieved through student-centered teaching practices that engage students in authentic scientific inquiry rather than teacher-centered approaches that include traditional lecture-centered teaching practices (Nember, 1997; Samuellowicz and Bain, 2001). To
Volatile Organic Metabolites as Indicators of Soil Microbial Activity and Community Composition Shifts

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The dynamics of soil microorganisms have important implications for the response of subsurface soil ecosystems to perturbations. Traditional indicators such as functional, community, activity, and carbon and nutrient pathway methods have been used to characterize soil microbial processes and ecological function; however, many of these indicators lack the ability to measure changes over large (e.g., landscape) spatiotemporal scales in soil environments. This research introduces the analysis of soil volatile organic compound (VOC) metabolites as nondestructive indicators of subsurface microbial activity and community composition as a function of varying environmental factors. Results of method validation using laboratory microcosms are presented, where VOC metabolites are characterized by gas chromatography and mass spectrometry (GC–MS) were related to CO₂ evolution as a measure of microbial activity and to community-level physiological profiles (CLPPs) and fatty acid methyl ester (FAME) community structure techniques. Results included the identification of 72 VOC metabolites produced from the soils, where significant (p < 0.05) differences in the estimated amounts and types of compounds produced were observed between treatments. Temporal measurements indicated similarity between VOC production and CO₂ evolution, where increased amounts over time were observed. Principal component analysis (PCA) and hierarchical cluster analysis showed that the VOC results clustered similarly to FAME and CLPP results. Our results suggest there is promise for the use of naturally produced VOCs as potential indicators of soil microbial ecosystems over large spatiotemporal dynamics and environmental perturbations.

Abbreviations: ATD, autothermal desorption; CLPP, community-level physiological profiles; FAME, fatty acid methyl ester; GC–MS, gas chromatograph mass spectrometer; LANWR, Laguna Atascosa National Wildlife Refuge; PCA, principal component analysis; VOC, volatile organic compound.

Characterizing the microbiological role in soil ecosystems is important because soil microorganisms significantly impact the C, N, P, and S biogeochemical cycles through biochemical processes including organic matter decomposition and mineralization, inorganic nutrient immobilization and assimilation, and organic nutrient accumulation (Neen, 1997). Therefore, soil microorganisms are vital to the overall health, quality, and function of soils (Zelles, 1999; Dahllöf, 2004; Gil-Sotres et al., 2005). Common techniques to characterize processes of quantitative significance to soil ecosystems usually include the use of microbial indicators. Microbial indicators are frequently utilized to determine the microbiological impact on soil ecosystems as well as the response of the microbial community to changing environmental factors (Jones and Bradford, 2001; Tocchini and Ovreås, 2002; Fang et al., 2006).

In general, these indicators can be placed into one of four methodological categories: (i) functional characterization methods, which includes the use of extracellular enzymes (Fiúna et al., 2006); (ii) taxonomic and community approaches, consisting of the use of DNA and ribonucleic acid studies, such as polymerase chain reaction–DNA and denaturing gradient gel electrophoresis (Ovreås, 2000; Marchner et al., 2001) and fatty acid and CLPP analyses (Bayes and Drinkwater, 1997; Bossio and Scow, 1998; Zelles, 1999; Widmar et al., 2001; Banowetz et al., 2006; Fang et al., 2006); (iii) microbial activity measurements, such as metabolite production inoxic and anoxic environments (Wood et al., 1993; Fierer et al., 2003; Lovley et al., 2004; Sell and Morse, 2006); and (iv) carbon and nutrient pathway studies, including the use of isotopic labeling (Boschker et al., 1998; Rochette et al., 1999; Fernandez et al., 2003; Padmanabhan et al., 2003; Scholl and Kuhn, 2004) and the study of organic carbon compounds (Hedges and Oades, 1997; van Hees et al., 2005).

Specific advantages and disadvantages are associated with each method. Generally, there are two ways an indicator may be a poor source of information— if there are many processes, sources, or events that may affect it, or if there are many intermediary steps before it is produced (e.g., CO₂ studies). An ease of measurement trade-off such as time, extraction procedures,
One-dimensional solute transport in a permeable reactive barrier–aerifer system

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[1] Transient semi-analytical and steady state analytical solutions to assess solute transport in a permeable reactive barrier (PRB)–aerifer system are developed on the basis of a multidomain approach of an up-gradient PRB and a down-gradient aerifer. Sensitivity analysis of input parameters in the solution is addressed through mathematical modeling. A designing equation from the developed steady state closed-form analytical solution is derived, and the accuracy of the equation is tested. The results confirm that the thickness and the first-order reaction capability of the PRB are two of the most important design considerations. Through sensitivity analysis, the reduction of the reactive capability of the PRB has a significant impact on the PRB performance. The aerifer reaction capability is found to be nonnegligible for the determination of the required thickness of the PRB, and its importance becomes greater when the PRB porosity becomes smaller because of mineral fouling.


1. Introduction

[2] In the past decade, the permeable reactive barrier (PRB) is perhaps one of the most widely applied technologies for remediation of chlorinated solvents, acid mine drainage, and other contaminants in groundwater [Beneden et al., 1997]. A PRB is an in situ remediation method that combines a chemical and/or biological treatment zone with subsurface fluid flow management [U.S. Environmental Protection Agency (USEPA), 1998]. The PRB is often installed in slab or trench configurations that are backfilled with zero-valent iron (ZVI), chelators, sorbents, and microbes [USEPA, 1998]. Research on the subject has been carried out on the geochemical aspect of reactive substances [Tratnyek et al., 1997; Beneden et al., 1997], the physical aspect of PRB performance, such as flow and transport characteristics [Gupta and Fos, 1999; Hunst and Shackelford, 2006], or design considerations, such as the spatial dimensions of PRB [Tratnyek et al., 1997; Eykholt et al., 1999; Rabideau et al., 2005]. More recently, chemophysical aspect of mineral fouling in a PRB system during its operation with consideration of aquifer heterogeneity has been studied [Ii et al., 2006]. The mineral fouling in a PRB will result in the reduction of the reaction capability as well as both the porosity and the permeability of the PRB. To achieve the best performance of remediation, the capture zone and residence time of a PRB are two important interrelated factors to consider, and both are associated with spatial dimensions, is particularly, the PRB thickness [Gupta and Fos, 1999; Hunst and Shackelford, 2006]. Since the early stage of PRB optimization studies, aquifer heterogeneity and anisotropy have been taken into account as important design features [Eykholt et al., 1999; Finner, 2004].


[4] The exit boundary of the PRB is no more than the interface between two different media: the upstream PRB and downstream aerifer. Also, for high-concentration plumes, it is often unable to configure a PRB with the necessary residence time to achieve maximum contaminated level (MCL) at the right exit face of the barrier because of cost and construction constraints. However, it may be feasible to exploit natural attenuation in the down-gradient aerifer to further reduce contaminant concentrations prior to reaching a compliance point. For the cases mentioned, an analytical tool from the multidomain approach can be efficiently applied to delineate the minimum barrier thickness required for a compliance safety. In this sense, a practical tool of delineating the optimized thickness of a PRB has not been fulfilled. In this study, a transient semi-analytical solution evaluating PRB performance is established with consideration of multidomains physical and chemical properties. A closed-form steady state analytical
What can be learned from sequential multi-well pumping tests in fracture-karst media? A case study in Zhangji, China

Jiazhang Qian · Hongbin Zhan · Jianfeng Wu · Zhou Chen

Abstract A fracture-karst aquifer is a karst aquifer with a fractured rock matrix, and its parameters are difficult to determine. Two sequential pumping tests in a fracture-karst aquifer system at the Zhangji well field of China are considered, one carried out before (in 2000) and one after (in 2005) the operation of a pumping station in the well field (2003–2005). The sequential tests serve multiple purposes. First, they provide a cross check of the parameters obtained. Second, they can be used to assess the effect of long-term groundwater exploitation of the aquifer. A three-dimensional finite-element transient flow model has been developed to simulate groundwater flow at the site. Generally good agreement has been found between the simulated and observed hydraulic heads for both tests. The hydraulic parameters obtained from the 2005 test are generally consistent with their counterparts from the 2000 test. However, a small but steady increase of hydraulic conductivities from 2000 to 2005 at the site has been observed. A 10-year prediction of groundwater resources has been made and indicates that the well field can accommodate the proposed 8.0 × 10^6 m^3/day exploitation rate under relative drought conditions without causing a steady decline of groundwater levels.

Keywords Numerical modeling · Hydraulic properties · Karst · Multi-well pumping tests · China

Introduction

A fracture-karst aquifer is a karst aquifer with a fractured rock matrix. Fracture-karst aquifers are widely distributed around the world and are important groundwater resources (White 2006, 2007; Mareschal et al. 2008). In northern China, karst development is not as complete as that in southern China and is usually associated with a fractured matrix, becoming a unique aquifer system named “fracture-karst” aquifer by many authors in China (Zhao and Cai 1991; Zhu et al. 1997; 2000; Wu et al. 2000, 2007). Despite the importance of fracture-karst aquifers, they are probably the least understood aquifer systems because of their highly heterogeneous and complex nature (White 2006, 2007). For long-term planning of the groundwater resources of fracture-karst aquifers, one has to find some way to characterize the aquifer systems to understand the groundwater flow and possible pathways of contaminant transport if the aquifers are polluted. Given the highly heterogeneous nature of these aquifers, the spatial distribution of aquifer parameters at local scales will vary greatly and are extremely difficult to predict, if not entirely impossible. Furthermore, the presence of preferential flow pathways such as karst conduits and large fractures may invalidate the use of Darcy’s law at local scales (Qian et al. 2006; White 2006).

Fortunately, for the purpose of long-term groundwater planning, aquifer parameters over large scales are probably more relevant and useful than those at local scales. Furthermore, averaged flow over large scales may actually be approximated by Darcy’s law reasonably well, although local-scale flow violates Darcy’s law. Therefore, an equivalent porous medium model (EPMM) can be applied (White 2007) as the local-scale heterogeneities of the karst aquifer are smoothed out, and it can be represented by an average hydraulic conductivity. White (2006, 2007) has further pointed out that the EPMM works best for aquifers in which the karstic-flow paths are dispersed and consist mainly of solution-widened fractures and works less well for aquifers with well-developed conduit systems. Several successful examples of the EPMM application include studying groundwater flow in...
Pachytesta crenulata, a new medullosoan ovule from the Pennsylvania of Iowa

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**ABSTRACT**

A new species of medullosoan ovule, *Pachytesta crenulata*, is described from the latest Atokan-earliest Briscoerian (early Moscovian) of Iowa. The ovule is approximately 5.5–6.0 mm long and 2.4–2.9 mm wide at the mid-point with three commissured primary ribs, three secondary ribs expressed at the apex, and a large number of sclerostegia ridges (8–24 between each primary rib-secondary rib pair), formed from interwoven bands of fibers. The micropyyle, defined by the epidermal cuticle of the endosperm, is flared at the tip and triangular in cross section. A collar of sclerostegial and nucellar tissue, 10 mm tall surrounds the micropyyle. The space enclosed by the collar is a triangular prism, with a primary rib at each edge and sides approximately 2.3 mm in length. The space between the microphyllum and the sclerostegial-nucellar collar appears to have been filled with thin-walled endosperm cells. At the ovule apex, lobes of nucellar tissue associated with the primary ribs partially occlude the top of the collar, forming a triangular opening with the flared tip of the micropyyle in the center. *Pachytesta crenulata* appears most similar to *P. composita* and *P. illinoensis*. All three ovules have tertiary ribs or ridges and secondary fibers in the sclerostegia; in both *P. illinoensis* and *P. crenulata*, a collar of sclerostegial and nucellar tissue surrounds the micropyyle. Based on these similarities, we place *P. crenulata* in Taylor’s (197A) 1965, Palaeozoic seed families: a monograph of the Americas species of Pachytesta, Palaenoochora, Ipatiev* [ed. *P. composita*–*P. illinoensis* group]. The condition of the sclerostegial and nucellar stalks of *P. crenulata* may indicate its developmental stage. Ovules having hollow fibers in the sclerostegial-micropylar stalks with a convex profile appear immature relative to ovules with filled fibers in the sclerostegial and deeply invaginated micropylar stalks. Although the pollination and fertilization status of most *P. crenulata* ovules remain equivocal, one mature ovule probably was pollinated. All of the immature ovules showed signs of seed protection.

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1. Introduction

Brunsvig (1874a,b) established the genus *Pachytesta* for large ovules having trigonal symmetry, three commissured ribs, a profound separation between the nucellus and the integument, and separate vascular systems for the nucellus and the integument, both consisting of discrete vascular bundles. He assigned two ovule species from the Stephanian (Kasimovian and Gzelian stages of the Pennsylvania) of France to the genus, *P. crenulata* and *P. gigantea*. Both species were illustrated in Brunsvig’s (1881) posthumous publication; Renault (1896) provided a more detailed description of the genus.

Hoskins and Cross (1946a) demonstrated that the compression-impression seed-ovule genus *Trigonocarpus* is a different preservational state of *Pachytesta*. Although *Pachytesta* has not been found attached to medullosoan foliage, a number of workers found *Trigonocarpus*, or similar, radially symmetric ovules, attached to medullosoan foliage (Kidston, 1904; Halle, 1927, 1929; Nelskla, 1931; Halle, 1933; Arnold, 1935, 1937, Hemingway, 1941; Jongsma, 1954; Langford, 1956; Bushine, 1961; Zodrow and McCarkish, 1960, Pfeiffer and Dickey, in Taylor and Taylor, 1993; Wittry, 2005). Most of these reports have been reviewed by Wagner (1968), Stid (1971), Taylor and Taylor (1993) and Cleal and Shute (2003). In compression-impression material it can be difficult to distinguish attached organs from disconnected organs preserved on top of one another. In addition, some attached "ovules" may represent pollen organs. Nonetheless, the available evidence supports the assignment of *Pachytesta* to the medullosoan seed ferns (Order Medullosoales; Family Medullosoaceae) (Stid, 1981; Cichan and Taylor, 1981).

In their 1946 monograph, Hoskins and Cross (1946a) reviewed the species of *Pachytesta* known at that time. Hoskins and Cross (1946b) described a new species of *Pachytesta*, *P. venus*, from the Angus Stria Mine, 0.8 mi northwest of Oklahoma, Iowa. To date, *P. venus* is the only species of *Pachytesta* to be described based on material from Iowa.

Stewart (1951, 1954, 1958) identified two new species of *Pachytesta*, *P. inumagulata* and *P. composita*, and moved two species formerly placed in other genera, *P. rhodostiperpermum* Illinoensis and *P. inumagulata* ovum, to the genus. He outlined three lineages of *Pachytesta*: *P. venus*, *P. iunagulata*, and *P. composita*. "Venusia" were placed in one lineage based on the following characters: well-developed ribs, extended micropyyle base, and micropylar ovule with a conspicuous stalk (Stewart, 1951, 1958) (Group 1, Table 1).
Cordaites in paleotropical wetlands: An ecological re-evaluation

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ABSTRACT

Cordaites in coal-flake-dominated permineralized peat from Pennsylvanian coals in Iowa have trees reconstructed as mangroves using root anatomy, leaf physiography, and geochemical data. In the peat bordering the coal, the Cordaites are ecologically similar to modern mangroves, which may indicate a tropical or subtropical climate. The Cordaites in the peat indicate a tropical climate, similar to the climate in the peat bordering the coal, which may indicate a tropical or subtropical climate. The Cordaites in the peat indicate a tropical climate, similar to the climate in the peat bordering the coal, which may indicate a tropical or subtropical climate.
3D polarimetric GPR coherency attributes and full-waveform inversion of transmission data for characterizing fractured rock

Douglas S. Sassen¹ and Mark E. Everett¹

ABSTRACT

Ground-penetrating radar (GPR) can detect and describe fractures to help us characterize fractured rock formations. A fracture alters the incident waveform, or wave shape, of a GPR signal through constructive and destructive interference, depending on the aperture, fill, and orientation of the fracture. Because the electromagnetic (EM) waves of GPR are vectorial, features exhibiting strong directionality can change the state of polarization of the incident field. GPR methods that focus on changes in waveform or polarization can improve detection and discrimination of fractures within rock bodies. An algorithm based on coherence, a seismic attribute that delineates discontinuities in wavelet shape, is developed for polarimetric GPR. It uses the largest eigenvalue of the time-domain scattering matrix when calculating coherency. This algorithm is sensitive to wave shape and is unbiased by the polarization of GPR antennas. Polarimetric coherency works better than scalar coherency in removing the effects of polarization on field data collected from a fractured limestone outcrop used for hydrologic experimentation. Another method, for time-domain full-waveform inversion of transmission data, quantitatively determines fracture aperture and EM properties of fill, based on a thin-layered model. Inversion results from field data show consistency with the location of fractures from reflection data. These two methods offer better fracture-detection capability and quantitative information on fracture aperture, dielectric permittivity, and electrical conductivity of the fill than traditional GPR imaging and scalar-coherency attributes.

INTRODUCTION

The detection of fractures and the identification of their aperture and fill materials is an important area of near-surface geophysical re-

search, with potential applications in fractured-rock hydrology and rock mass studies for civil and mining engineering. Fractures can alter the hydraulic and mechanical properties of the rock mass significantly, and these bulk properties often differ considerably from laboratory measurements on rock samples. Consequently, geophysical techniques such as ground-penetrating radar (GPR), which provide spatially continuous subsurface information, can enhance fractured-rock descriptions. GPR increasingly is being used for near-surface characterization of fractured rocks because of its high-resolution imaging capabilities and good penetration (~10 m) in most rock materials.

Early GPR studies of fractured rock used 2D scalar data (e.g., Stevens et al., 1995). More recently, Van Gestel and Stoffa (2001) and Seol et al. (2001) have used Alford rotations to demonstrate the way 2D multicomponent GPR can determine the strike direction of fractures. Toftias et al. (2004) demonstrate that the polarization properties of GPR can help detect vertical fractures. Toftias and Roehl (2006) investigate multipolarization GPR for characterizing thin, vertical fracture properties. Grasmuck et al. (2005) show the benefits of single-component 3D GPR with high spatial sampling for imaging fractures. A 4D-GPR survey, i.e., repeated 3D surveys in time, has been used to track saline tracer flow in a subsurface fracture (Talley et al., 2005). Joannis et al. (2006) use the face of a vertical cliff to acquire vertical and horizontal reflection profiles and horizontal transmission profiles to delineate fractures for a rock-mass stability study. There is still room for methods that enhance fracture detection by utilizing the vectorial nature of GPR and that allow for quantitative descriptions of fracture aperture and fill materials through geophysical inversion techniques.

The GPR response of a given fracture depends on the polarization and bandwidth of the GPR antennas plus the incident angle of the waves on the fracture. A wave reflected from a thin layer is distorted by the constructive and destructive interference that occurs from multiple internal reflections (Widess, 1973). Additionally, the amount of received electromagnetic (EM) backscatter depends

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Ecohydrogeophysics at the Edwards Aquifer: insights from polarimetric ground-penetrating radar

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ABSTRACT
Three-dimensional multicomponent ground-penetrating radar (GPR) reflection data and horizontal GPR transmission profiles were acquired and analyzed to better understand the interaction of vegetation with subsurface flow conduits at a hydrologic experimentation site. Previous researchers conducted a set of shallow (<2.5 m) subsurface hydrology experiments during simulated rainfall events within a small plot (7 m x 14 m) on the fractured and laminated limestone of the Edwards Aquifer region near San Antonio, Texas, USA, to better understand the influence of Juniperus ashei brush control on the local hydrology. Tracer experiments showed a high degree of variability in tracer recovery, advection speed and concentration depending on the location of the application of the tracer. Both 3D multicomponent GPR reflection images and coherency and inversion of GPR horizontal transmission profiles were utilized to identify the main conduits of flow within the experimentation site in order to explain the observations of the experiments. The 3D multicomponent GPR and coherency images revealed that the most obvious potential conduits run nearly parallel with the observation trench. Inversions of the horizontal transmission profiles indicate that some conduits are filled with soil while others have no fill. This information helps explain the high spatiotemporal variability observed in the tracer data. Additionally, the GPR and hydrologic experiments suggest that Juniperus ashei significantly impacts infiltration by redirecting flow towards its roots occupying fractures within the rock. This study demonstrates that GPR provides a noninvasive tool that can improve future subsurface ecohydrologic experimentation.

INTRODUCTION

The consequences of anthropogenic alteration of natural ecosystems are of pressing global concern, with implications for both water resources and atmospheric carbon levels. Changes in land use practices and fire control have allowed woody brush to expand into grasslands, deserts and disturbed agricultural land. The encroachment of brush and forest has been linked to decreases in water yields (Buch and Hewlett 1982). Brush encroachment in the United States is thought to lead to a significant sequestration of atmospheric carbon (122 million tons C/year from 1980–1999) in the form of increased biomass (Houghton et al. 1999; Pacala et al. 2001). These studies may be of limited applicability to all ecosystems, especially environments in which landscape physiography significantly impacts water and carbon fluxes (e.g., Huxman et al. 2005).

The lack of adequate subsurface characterization has led to an underestimation of the influence of subsurface processes on ecosystems. The complexity of the subsurface has important influence on ecohydrology. For example, Jackson et al. (2007) showed that when subsurface variations in soil organic carbon are considered, there is a negative relationship between brush invasion and stored carbon in humid environments. Wilcox et al. (2008) showed that increased woody brush cover is correlated to increased, rather than reduced, groundwater volumes in an environment that is dominated by subsurface karst flow, rather than porous media flow. There is a need for non-destructive methods to investigate shallow (<10 m) subsurface ecological interactions. In this paper we explore the use of ground-penetrating radar (GPR) in a plot scale study of the impact of Juniperus ashei, an invasive brush species, on fractured epikarst limestone hydrogeology in central Texas, USA.

In the semiarid region of the Southwest United States, human settlement over the past 150 years has altered the natural environment of grassland and savanna into shrubland through the suppression of natural fires and increased grazing (Van Arkel 2009). The consequent proliferation of Juniperus ashei, a deep rooted evergreen shrub, within the central Texas rangeland is hypothesized to induce recharge into local streams and the Edwards Aquifer (Wilcox 2002; Olenicz et al. 2004). Careful manage-
Quantifying the Reservoir Heterogeneity: A Case Study of Clastic Reservoirs, Bohai Bay Basin, China
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Summary
Accurate high-resolution reservoir models are critical to better understanding of the reservoir heterogeneity for enhanced oil recovery. We define three parameters: permeability distribution coefficient ($S_p$), variation coefficient ($V_p$), and contrast coefficient ($N_p$), to characterize quantitatively the heterogeneity levels. Incorporation of these parameters in reservoir facies models proves to help build quantitative reservoir heterogeneity models, including detailed delineation of intrabed and interbed heterogeneity within the reservoir. This method has been successfully tested in two pilot areas in the Bohai Bay Basin using core and log data and greatly enhanced the thermal production. Further upsampling of these heterogeneity parameters from log to seismic scale and their seismic signature identification will enable us to predict the reservoir connectivity in interwell regions.

Introduction
Reservoir heterogeneity plays an important role in reservoir performance. The factors that affect production are reservoir continuity, connectivity and the spatial distribution of permeability (Hovadin and Lame, 2007). Geological model and geostatistical model have been widely applied on these studies (Lame and Lame, 2004, and many others). Some quantitative methods have been attempted on describing reservoir heterogeneity. Dykstra-Parsons coefficient of permeability variation is a common descriptor of reservoir heterogeneity. It measures reservoir uniformity by the dispersion or scatter of permeability values. Jenson and Lake used D-P coefficients, Lorenz coefficient and coefficient of variations to measure the heterogeneity. Jenson and Cirit (1990) developed a new method for estimating the D-P coefficient to characterize reservoir heterogeneity.

In this study, we develop a new set of permeability coefficients to build reservoir heterogeneity model with well log and core data for highly heterogeneous reservoirs in Bohai Bay Basin.

Clastic heavy oil reservoirs of lower Tertiary age, in the Bohai Bay basin, China, have been under thermal production for more than twenty years. However, production performance has remained unstable, largely due to the fact that the producing formations are highly heterogeneous. A better understanding of reservoir heterogeneity and establishment of accurate high-resolution reservoir heterogeneity models are highly needed to optimize the field development.

The focus of the study is SHUA-E reservoir A which is located at the western slope of the west depression in the Bohai Bay basin, characterized by thick sandstone and conglomerate deposition in the middle and lower fan delta environment. It has been divided into seven sand units, and the top five units are the major producing formations with average porosity of 26% and permeability in the range 100 to 1056 md (Figure 1).

![Figure 1: Reservoir A cross-section](image.png)

Methods
In order to identify the reservoir heterogeneity accurately, quantitative heterogeneity levels need to be determined rather than qualitative descriptions. The important step is to develop the relationship between a heterogeneity level and a lithofacies model that is genetically related to deposition patterns.

Quantitative heterogeneity levels are determined by calculation of permeability variation coefficient ($V_p$), dart coefficient ($S_p$) and contrast coefficient ($N_p$).
Determination of the volcanostratigraphy of oceanic crust formed at superfast spreading ridge: Electrofacies analyses of ODP/IODP Hole 1256D

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The objective of this study is to construct a representative volcanostratigraphy of Ocean Drilling Program Hole 1256D, the first complete penetration of intact upper oceanic crust formed at a superfast spreading rate. An accurate knowledge of the volcanostratigraphy is vital to understand processes of crustal construction and submarine magmatism and to estimate chemical exchange with seawater, but this is rarely achieved due to very low recovery rates in most basement holes. We used two approaches to determine the rock types that form the wall rocks in the basement sections of Hole 1256D: (1) user guided interpretations of electrofacies acquired by imaging tools combined with other wireline tools; and (2) the use of an artificial neural network to objectively classify the responses of all available logging information. Great availability of formation microscanner (FMS) images provided superior coverage of the borehole wall compared to previous attempts at core-log integration. This has resulted in more confident and detailed lithologic classifications, such as with the distinction between pillows and different styles of brecciation. Ten lithology types are suggested for a volcanostratigraphy model: massive flows, ponded lava, fractured massive flows, fragmental flows, thin flows or thick pillows, pillows, breccias, dikes in dike complex, isolated dikes, and gabbros. Three major lithology types in the extrusive section are massive flows (both massive and fragmented massive flow, 22%), fragmental flows (32%), and breccias (19%). Pillow lavas make up only 1.9% of the volcanic section and are confined to a 100 m interval. Below the extrusive section, subvertical contacts interpreted to be dike margins are typically observed every 1 to 2 m with brecciated zones along the contacts. The dikes dip steeply to the northeast indicating slight rotation away from the ridge axis. We used an artificial neural network (ANN) approach to determine a quantitative lithostratigraphy. The ANN is most strongly influenced by porosity and alteration degrees and the resulting stratigraphy most closely resembles the above classifications when clustered by FMS texture as opposed to lithologic interpretation. The ANN thus provides a porosity-based stratigraphy of the basement rather than the traditional lithology-based stratigraphy.
A numerical solution for non-Darcian flow to a well in a confined aquifer using the power law function

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\TITLE{A numerical solution for non-Darcian flow to a well in a confined aquifer using the power law function}
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\KEYWORDS{Non-Darcian flow, Power law, Finite difference method, Laplace transform, Linearization method}
\ABSTRACT{In this study, we have obtained numerical solutions for non-Darcian flow to a well with the finite difference method on the basis of the Izbash equation, which states that the hydraulic gradient is a power function of the specific discharge. The comparisons between the numerical solutions and the Boltzmann solutions and linearization solutions have also been done in this study. The results indicated that the linearization solutions for both the infinite-length-diameter well and the finite-length-diameter well agree very well with the numerical solution at extreme times, while the linearization method overestimates the dimensionless drawdown at early and moderate times. The Boltzmann method works well as an approximate analytical solution for the infinite-length-diameter well. Significative differences have been found between the Boltzmann solution for a finite-diameter well and the numerical solution during the entire pumping period. The analysis of the numerical solution implies that all the type curves inside the well for different dimensionless non-Darcian conductivity \(k_b\) values approach the same asymptotic value at early times, while a larger \(k_b\) leads to a smaller drawdown inside the well at late times. A larger \(k_b\) results in a larger drawdown in the aquifer at early times and a smaller drawdown in the aquifer at late times. Flow approaches steady-state earlier when \(k_b\) is larger.}

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\section{Introduction}

Darcy's law has been used to simulate groundwater flow for more than 100 years. However, when the groundwater flow velocity becomes sufficiently high or sufficiently low, flow can be non-Darcian (e.g. Pokhriavare-Kochua, 1962; Wright, 1964; Bass and Regnart, 1975; Burch and Angsey, 1989; Wu and Emery, 1991; Wood, 1995; Zeng and Grigg, 2006). In this study, we only consider the post-linear flow for the high velocities near the pumping wells.

A key issue in non-Darcian flow is to quantify the relationship between the specific discharge and hydraulic gradient. Two formulae have been commonly used. The first one is the Forchheimer equation (Forchheimer, 1901), which states that the hydraulic gradient is a second-order polynomial function of the specific discharge. It should be pointed out that there are some alternative ways to present the Forchheimer equation (e.g. Thiem, 1906; Izbash, 1931; Nield, 1981). Considering that a local time derivative inertial term and an advective inertial term should be added with the hydraulic gradient on the left-hand side of the equation, while the so-called "Brinkman viscous term" should be added with the specific discharge on the right-hand side of the equation. Meanwhile, Moustopoulos (2007) pointed out that these extra terms are negligible only for very short times. The second one is the Izbash equation (Izbash, 1931), which states that the hydraulic gradient is a power function of the specific discharge. Many experimental data indicate that both these two functions can describe non-Darcian flow very well (Bordier and Zimmer, 2000; Yamada et al., 2005).

Up to now, many analytical solutions for non-Darcian flow have been presented. For instance, Sen (1981, 1984a,b, 1989, 1990) have obtained analytical solutions for non-Darcian flow to a well using the Boltzmann transform method, a special form of the so-called...
An analytical solution of two-dimensional reactive solute transport in an aquifer-aquitard system

Hongbin Zhan,1 Zhang Wen,2 and Guangrui Gao3

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[1] This article presents an analytical study of two-dimensional reactive solute transport in an aquifer-aquitard system. Advection, longitudinal and vertical dispersion, first-order irreversible decay, and linear sorption are included for aquifer transport. Advection, vertical diffusion, first-order irreversible decay, and linear sorption are considered for aquitard transport. This study solves transport equations in the aquifer and aquitards simultaneously and maintains continuities of concentration and mass flux at the aquifer-aquitard interfaces. The transport equations are first solved in Laplace domain, and the solutions are then inverted numerically to yield solutions in the real time domain (the Zhan solution). Concentration profiles in the aquifer and the aquitards are obtained and mass transported to the aquitards is also calculated. Closed-form steady state solutions of concentration and mass have been obtained. The Zhan solution is compared with solutions derived with the averaged volumetric sink/source approach (the AA solution). The AA solution substantially overestimates the concentration and mass in the upper aquitard when an upward velocity exists in the aquifer. The penetrating depths of the solute in the aquitard are similar for the AA solution and the Zhan solution.


1. Introduction

[2] Significant efforts have been put forward by hydrologists to study impact of low-permeability media on solute transport in the past several decades [Sadicky et al., 1985, Parker et al., 2004, Liu et al., 2007]. Diffusion in the low-permeability media is found to be a very important mechanism of transport. At present, analytical studies associated with transport in aquifer-aquitard systems only deal with the transport equation in the aquifer by approximating the diffusive mass flux at the aquifer-aquitard interface as a volumetric sink/source term [Tang et al., 1991; Tang and Alfi, 1992a, 1992b]. The implication of this approach is that the transverse mixing across the thickness of the aquifer is so rapid that a thickness-averaged concentration can be used. This approach may work well for transport in a fracture-matrix system since the aperture of a fracture is often very small and the mixing of solute across the fracture aperture maybe rapid, but its application to an aquifer-aquitard system is questionable because the aquifer thickness is often of the order of meters to tens of meters or even larger, thus mixing of solute across the aquifer thickness cannot be quickly established. Sadicky et al. [1985] have proposed an alternative method of treating the diffusive flux at the aquifer-aquitard interface as a boundary condition rather than a sink/source term in the governing equation of transport in the aquifer, but they have neglected longitudinal dispersion in the aquifer. In a real aquifer, the longitudinal dispersivity is often quite large (at meter to tens of meters scale) and cannot be ignored.

[3] Advection in the aquitard is rarely considered in previous analytical approach of transport in aquifer-aquitard systems. Most confined aquifers are recharged by leakage through overlying aquitards, which means, in case of transport, that there will be advection in the aquitards. Furthermore, the aquitard often has a high capacity to adsorb contaminant relative to the permeable aquifer due to its large specific surface area and fraction of organic carbon. Therefore, the aquitard often has a larger retardation factor than that of the aquifer (if a linear isotherm can be used to describe the sorption). Mineralogy and biological environment of the aquitard are also quite different from the permeable aquifer, thus the rate of biodegradation of contaminant in the aquitard is also very different from that in the aquifer.

[4] The purpose of this study is to use an analytical approach to understand reactive solute transport in an aquifer-aquitard system considering the first-order biodegradation or radioactive decay, retardation, aquitard diffusion, and aquitard advection. We will solve the transport equations in the aquifer and the aquitards simultaneously by maintaining mass balance at the aquifer-aquitard interfaces. Zhan et al. [2009] have solved a similar problem for conservative solute transport in an aquifer-aquitard system. The limitations of this study are that it does not consider the aquitard heterogeneities, the surface effect at the aquifer-aquitard interface, and the effect of gravitational settling.
Analytical solution of two-dimensional solute transport in an aquifer–aquitard system

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ABSTRACT

This study deals with two-dimensional solute transport in an aquifer–aquitard system by maintaining rigorous mass conservation at the aquifer–aquitard interface. Advection, longitudinal dispersion, and transverse vertical dispersion are considered in the aquifer. Vertical advection and diffusion are considered in the aquitard. The first-type and the third-type boundary conditions are considered in the aquifer. This study differs from the commonly used averaged approximation (AA) method that treats the mass flux between the aquifer and aquitard as an averaged volumetric source term in the governing equation of transport in the aquifer. Analytical solutions of concentrations in the aquitard and aquifer and mass transported between the aquifer and upper or lower aquitard are obtained in the Laplace domain, and are subsequently inverted numerically to yield results in the real time domain (the Zhu method). The breakthrough curves (BTCs) and concentration profiles in the aquifer obtained in this study are drastically different from those obtained using the AA method. Comparison of the numerical simulation using the model MT3DMS and the Zhu method indicates that the numerical result differs from that of the Zhu method for an asymmetric case when aquitard advective reactions are at the same direction. The AA method overestimates the mass transported into the upper aquitard when an upward advection exists in the upper aquitard. The mass transported between the aquifer and the aquitard is sensitive to the aquitard Peclet number, but less sensitive to the aquitard diffusion coefficient.

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1. Introduction

Interaction between aquifers and aquitards is an important process affecting flow and transport in subsurface flow systems. Most aquitards consist of silt and clay and are well capable of storing water and solute, due to their large values of porosity. Thus when a solute in an aquifer contacts a previously solute-free aquitard, a concentration gradient exists across the aquifer–aquitard interface; and molecular diffusion will drive the solute into the aquitard. Furthermore, leakage often exists across the aquitard, thus advection in the aquitard will be another important mechanism for solute transport there.

Diffusion at the aquifer–aquitard interface is somewhat similar to diffusion at the matrix-fracture boundary (Tang et al., 1981; Sudicky and Frind, 1982, 1984; Fujikawa and Fujita, 1990; Liu et al., 2004). The difference is that the aperture of a fracture is much smaller than the aquitard thickness and the flow velocity in the fracture is often much greater than that in the aquifer under the same hydraulic gradient. Many studies on fractured media have shown that matrix diffusion is the primary factor for retarding contaminants in the fractures (e.g. Neretnieks, 1980; Raasveld and Neretnieks, 1981; Neretnieks et al., 1982; Moreno et al., 1985; Liu et al., 2004). Aquitard diffusion was shown to be the controlling factor affecting solute transport in laboratory experiments by Sudicky et al. (1985), Starr et al. (1985), Young and Ball (1998), and in numerous field aquifer studies such as Gifford et al. (1984), Johnson et al. (1989), Ball...
Conditions during syntectonic vein formation in the footwall of the Absaroka Thrust Fault, Idaho–Wyoming–Utah fold and thrust belt

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ABSTRACT
The Twin Creek Limestone in the footwall of the Absaroka thrust sheet contains three sets of low-normal syntectonic calcite veins. Vein formation occurred during Cretaceous motion along the Absaroka thrust fault as indicated by (1) crosscutting relationships among these vein sets, (2) a previously dated solution cleavage, and (3) calcite twin analysis. Fluid inclusions in the veins and overburden estimate constraining inclusion entrapment temperatures to be between 175 °C and 328 °C. Results from stable oxygen isotopes indicate that the host and vein fluid compositions were in near isotopic equilibrium. Applying both reasonable geothermal gradients and constraints on overburden temperature yields fluid pressures during vein precipitation that are near hydrostatic. All data taken together suggest both that vein formation within the Twin Creek Formation occurred in a relatively closed system, and that the veins filled near hydrostatic fluid pressure. Because the veins fill preservatory cracks, vein filling might not reflect the maximum fluid pressure that existed during the complete vein forming process. © 2009 Elsevier Ltd. All rights reserved.

1. Introduction
Although abnormal fluid pressures have been invoked to explain the apparent weakness of both thrust fault zones and thrust wedges (e.g. Hubbert and Rubey, 1959; Davis et al., 1983; Dahlen et al., 1984), direct evidence for abnormal fluid pressure in ancient continental margin thrust belts is sparse (e.g. Yorke et al., 1980; Montomoli et al., 2001; O'Hara and Haak, 2002; Montomoli et al., 2005; Mazzarini and Iida, 2007). Several arguments and lines of indirect evidence have generally been used to infer the existence of abnormally high fluid pressures in ancient thrust belts. The first is uniformitarianism. Drilling records from the Taiwan fold and thrust belt as well as other active accretionary prisms confirm that abnormally high fluid pressures exist in this tectonic setting at present (e.g., Suppe and Wittke, 1977; Moore et al., 1982). The inference is that accretionary prisms and continental margins undergoing contraction are sufficiently similar so that processes occurring now in the former probably occurred in the past in the latter. The second is vein studies. The presence of syntectonic veins may indicate that fluid pressures were high at the time of their formation because abnormal fluid pressure is needed to lower the driving stress required to open and propagate fractures (e.g. Segall and Pollard, 1983; Pollard and Segall, 1987; Olson and Pollard, 1991). To the extent that veins are hydrofractures, data from both their shapes and fluid inclusions contained within the vein fillings may provide information on the fluid pressure during vein formation. In addition, the compositions of syntectonic veins have been studied by a variety of means to understand the fluid source and composition (e.g. Rye and Bradbury, 1988; Briel and Katz, 1996; Bottomley and Veizer, 1992; Shemesh et al., 1992). These studies have shown that small scale cross and longitudinal variations in trace metals and stable isotopes of both oxygen and carbon may be preserved. The veins may also preserve minerals that precipitated from fluids in equilibrium with rock of composition significantly different from the local host (e.g., Rye and Bradbury, 1988; Briel and Katz, 1996); the fluid sources for veins of different generations may also be determined (Gao et al., 1992; Shemesh et al., 1992). In some cases, closed system conditions seem to better match the data (Taubin, 2004).

Fluid inclusions within syntectonic veins have also been examined to place constraints on fluid pressure at the time of vein growth (e.g. Srivastava and Engelder, 1990; Freeman and Dunne, 1995; Wiltschko et al., 2002).
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Determination of Dominant Biogeochemical Processes in a Contaminated Aquifer-Wetland System Using Multivariate Statistical Analysis

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Biogeochemical reactions in sediments are controlled by linked biological, physical, and chemical processes including hydrologic fluctuations, seasonal changes in temperature and biological activity, and rock-water interactions (Allee et al., 1996; Dahnk et al., 1998; Donahoe and Liu, 1998; Eser and Rosen, 1999; Kemp et al., 1992; Koretsky et al., 2003; Neubauer et al., 2005). These factors interact to create different hydrochemical facies that change temporally and spatially (Thayne et al., 2004). Variability in type and concentration of organic matter, availability of electron acceptors, chemical composition of the lithology, biological activity and hydrogeologic conditions of the system will determine fluctuations in the redox reactions occurring in situ (Koretsky et al., 2003) including aerobic respiration, nitrate reduction, iron/manganese reduction, sulfate reduction, and methanogenesis. These reactions occur in sequential order according to thermodynamic energy yields (Champ et al., 1979; Prevolick et al., 1979; Meyerson et al., 2004). However, in dynamic environments such as wetlands and anaerobic aquifers, these processes are linked and can coexist reflecting the complexity of the system. In biogeochemical studies, these processes are often interpreted from the analysis of geochemical parameters such as redox couples (e.g., H⁺S/S²⁻ and SO₄²⁻). One approach with this approach is that many geochemical parameters are affected by multiple hydro-bio-geo-chemical processes. Thus input processes are important to determine the correlations between parameters to identify the contributing process(es) for each parameter. These correlations can then give insights into the dominant biogeochemical processes in space and time within a given system.

In a wetland-aquifer system the distribution of redox processes respond to solute transport processes, biological activities, and solid-phase composition, which all can vary on small spatial scales (Hunt et al., 1997; Brune et al., 2000; Kappler et al., 2005). Hydrologic fluctuations, such as aquifer recharge, provide a mechanism for the delivery of electron acceptors or electron donors to a discrete zone. The availability of these transported solutes (e.g., electron donors and acceptors) can enhance microbial activity and in turn result in microbial community shifts. Biological activity is also impacted by seasonal changes in vegetation growth, which exerts an important control on redox processes. For example, in root zones oxygen is sufficient.
Plasticity and diffusion creep of dolomite

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ABSTRACT

Natural and synthetic dolomites have been shortened in triaxial compression experiments at temperatures of 400–650 °C, equilibrium CO2 pore pressure, effective confining pressures of 50–400 MPa, and strain rates of 10^{-6} to 10^{-3} s^{-1}. At low temperatures (T<700 °C) natural and synthetic dolomites exhibit high crystal-plastic strengths (i.e., 600 MPa) both for coarse-grained (246 μm) and fine-grained (2 μm and 12 μm) samples; differential stresses vary little with strain rate or temperature and microstructures of coarse-grained samples are dominated by twins and subcritical dislocation. An exponential relation (i = i_0 exp[(σn-n_0)] between strain rate i and differential stress (n−n_0) describes the crystal plasticity of dolomite at a fixed P_f and T, with n = 0.079 (±0.01) MPa^{-1} and T = 0.023 (±0.03) MPa^{-1} for coarse- and fine-grained materials, respectively. However, measured values of (n−n_0) increase with increasing temperature, a trend that has been observed for dolomite single crystals but cannot be described by an Arrhenius relation. At high temperatures (T>800 °C for coarse, T>700 °C for fine), dolomite strengths are reduced with increasing temperature and decreasing strain rate, but the mechanisms of deformation differ depending on grain size; high temperature flow strengths of coarse-grained dolomite can be described by a power law i = i_0 [(σ−σ_0)]^{n} exp(-H/T) with a large value of n (>5) and a ratio of parameters H/T (n = 60 (±5)) kJ/mol. Microstructures of coarse-grained samples deformed at T>800 °C show evidence of dislocation creep with little mechanical twinning. High temperature flow strengths of fine-grained synthetic dolomite fit a thermally activated Newtonian law, where the effective n = 1.28 (±0.15) and H/T = 280 (±45) kJ/mol, consistent with diffusion creep. The change in mechanical response of coarse-grained natural dolomite with increasing temperature represents a transition from twinning and slip with little or no recovery to dislocation creep, while the change in response of fine-grained synthetic dolomite represents a transition from crystal plasticity to dislocation creep. The combined results for coarse- and fine-grained dolomites define a deformation mechanism map with fields of crystal plasticity, dislocation creep, and diffusion creep. Strengths of coarse-grained dolomite in the crystal plasticity and dislocation creep fields are much larger than strengths of calcite rocks deformed by similar mechanisms. In contrast, strengths of fine-grained dolomite deformed by diffusion creep are more comparable to those of fine-grained calcite, suggesting little contrast in rheology.

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1. Introduction

As shallow marine sediments at continental margins, carbonates are commonly deformed during orogenic collision. Thus, the mechanical properties of sediments consisting primarily of calcite and dolomite govern the stresses during collision and the deformation seen in many orogens (Heitzmann, 1987; Burbank, 1980; Busch and

van der Pluijm, 1995; Bestmann et al., 2000; Moll et al., 2000; Ulrich et al., 2002).

Field observations indicate that dolomites are stronger than calcite-rich carbonates. Dolomites often appear fractured while adjacent limestones and marbles may exhibit substantial internal strains (Woodward et al., 1991; Erickson, 1994; Burch and van der Pluijm, 1995; Bestmann et al., 2000). Interlayers of dolomites and limestones appear to lead to ramp-flat geometries of thrust faults (Heitzmann, 1987; Burbank, 1980; Burch and van der Pluijm, 1995; Bestmann et al., 2000; Moll et al., 2000; Ulrich et al., 2002). Flat-lying decollements develop within weak calcite-rich units while ramps and high-angle brittle faults develop across strong dolomite units (e.g., Woodward et al., 1991; Erickson, 1994).

Early experimental studies are in broad agreement with these field studies, with fracture and flow strengths significantly higher for
STABLE ISOTOPE AND Sr/Ca PROFILES FROM THE MARINE GASTROPOD CONUS ERMEINEUS: TESTING A MULTIPROXY APPROACH FOR INFERRING PALEOTEMPERATURE AND PALEOSALINITY

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ABSTRACT

This study tests the fidelity of shallow-water gastropod skeletons as multiproxy archives of paleoenvironmental change by comparing isotopic and trace-metal analyses of specimen Conus ermineus. Four adult specimens were collected live from Stetson Bank in the northwestern Gulf of Mexico during the summer of 2003. Shells were sampled along axes of growth to produce time-series profiles spanning up to 8 years. δ18O and Sr/Ca profiles show seasonal cyclicity modified by fast summer and slow winter shell growth. The profiles were combined to estimate paleosalinity. This yields variable results that overestimate salinity range; nevertheless, annual salinity minima and maxima are still evident. The overestimates are attributed to inter-specimen Sr/Ca variability and error in the δ18O-exp salinity regression. Profiles of δ13C show seasonal variation superimposed on a decreasing ontogenetic trend, the latter attributed to decreasing metabolic efficiency also reflected by an ontogenetic increase in Sr/Ca. Seasonal δ13C variation reflects changes in the δ13C of dissolved inorganic carbon (δDIC). Salinity and δ18Oexp at Stetson Bank strongly correlate (R² = 0.80, p < 0.0001), and shell δ18Ominas coincide with local salinity minima following times of peak river discharge. These δ18Ominas terminate during annual shell current reversals. Low-salinity waters directly account for less than half the variability in shell δ18O but enhance summer stratification and trap respired CO2 from sediment pore waters. Specimens from this study show mean δ13C values 1% lower than C. ermineus collected from Stetson Bank in 1971, reflecting the decrease in δ13Cexp from anthropogenic CO2.

INTRODUCTION

This study explores the factors controlling the oxygen and carbon isotopic signals of Conus shells and the commonalities between vital effects in carbon isotopes and Sr/Ca, utilizing the Sr/Ca data of Sosdian et al. (2006). The study tests the use of oxygen isotopes and Sr/Ca data to estimate salinity and examines carbon isotopes as paleoenvironmental proxies for carbon cycling and salinity change. The results provide new constraints on the application of isotopic and trace-metal compositions of gastropod shells as paleotemperature and paleosalinity proxies and demonstrate the application of δDIC as an indicator of fossil fuel CO2 flux into the oceans.

Studies of ancient climate change rely heavily on mean annual temperatures (MATs) derived from the oxygen-isotope ratios (δ18O) of marine invertebrate skeletons (e.g., foraminifera, brachiopod, and molluscan shells). These studies have yielded volumes of information, allowing climate variability to be determined at resolutions of 103-104 years (e.g., Shackleton and Opdyke, 1973; Oppo et al., 1986; Miller et al., 1987; Zachos et al., 2001; Schlosser et al., 2005). Examinations of MAT variations alone, however, do not adequately explain biotic response to climate change. There are some extinction events in the geologic record in which significant MAT change is not observed, but climate change may still be a factor. For example, Ivany et al. (2000) propose that the late Eocene-Oligocene extinction was triggered by a rapid decline in the winter temperature. Whether this winter cooling was abrupt or gradual is debated (e.g., Kobashi et al., 2001), but the similar patterns of seasonal temperature change may be related by annually sampling acritarchs, benthic foraminifera, coral skeletons, and brachiopod and molluscan shells.

Cenozoic records of seasonality are well expressed in mollusks (e.g., Andersson and Scharitz, 2000; Kobashi et al., 2001), whose long life spans and rapid shell growth allow isotopically derived, seasonal temperature profiles to be constructed spanning up to a decade or more. The fidelity of molluscan isotopic profiles with respect to true seasonal temperature change, however, is limited by several biologic factors affecting shell growth (Goodwin et al., 2003; Wilson et al., 2003; Ivany et al., 2003). Otolithic growth and orientation of growth can also occur during summer or winter months, depending on the temperature tolerances of some species, so that the warmest or coldest months of the year are poorly represented in their shells. These factors can result in seasonal isotope profiles that underestimate true seasonal temperature ranges.

Additionally, the accuracy of paleotemperature determination is limited by uncertainties in the 206Pb/204Pb of the seawater (δ18Owater) in which ancient organisms grew. This is particularly true in shallow, marginal marine environments from which much of the fossil record is derived, where δ18Owater can be highly variable due to localized effects of freshwater input and evaporative loss. For example, a salinity decrease of 2 psu (practical salinity units) can result in a 1-2°C overestimation of paleotemperature (Falkowski et al., 1983). While such salinity variations are common in near-shore environments, even greater variations of up to 25 psu can occur in near-shore settings (Kobashi et al., 1998). Therefore, it is vital to constrain paleo-δ18Owater for accurate paleotemperature determination.

Researchers have explored the utility of trace-metal proxies in isotopic carbonates to better constrain paleotemperatures and δ18Owater. Sosdian et al. (2006) studied the potential of Sr/Ca in Conus shells as a salinity-independent proxy for seawater temperature. They showed that the relationship between Sr/Ca and temperature is complex and

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Can levogluconan be used to characterize and quantify char/charcoal black carbon in environmental media?

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A B S T R A C T

The heterogeneous nature of pyrogenic carbon, also known as black carbon (BC), still stands in the way of comprehensive determination of the total proportion of contribution derived carbon in environmental mixtures. Char and charcoal occur mostly in the low temperature region of the BC continuum and as such are characterized using specific chemical and physical properties that set them apart from the more condensed forms of high temperature BC species (i.e., soot). This study aimed to assess the feasibility of using the molecular marker levogluconan, exclusively produced from hemiacetals of cellulose combustion, to characterize and quantify char BC in the environment. A second objective was to compare the results from the molecular analysis with those from acid dichromate oxidation in terms of char BC characterization.

First, we examined levogluconan levels in a suite of BC materials derived from biomass burning and fossil fuel combustion, as well as non-BC materials (coal and melanodrin). The results confirm that levogluconan is inclusively in the char BC materials, derived from biomass combustion. However, a large variability in levogluconan yield was observed among the different char BC materials.

To understand the causes of such variability, we analyzed levogluconan in three series of laboratory-produced char samples (n = 23) made from honey mesquite (Prosopis glandulosa), cypress (Taxodium sp.), and kahikate (Pinus taeda) under controlled combustion conditions (500–1050°C, 0.5–5 k). The results show that temperature is the most influential factor affecting levogluconan yield in char. Combustion duration, on the other hand, had no influence on yield. Notably, levogluconan was only detectable in low temperature char samples (500–350°C), with maximum yield obtained from samples produced at 350°C, regardless of plant species. Large differences in levogluconan yield were also observed across species. This taxonomic difference could not be corrected simply on the basis of hemicellulose and cellulose content, indicating that the relationship between combustion and levogluconan formation is a complex function of many factors. Our observations also demonstrate that levogluconan can hardly be used quantitatively for the determination of char BC in environmental samples since such samples often represent mixtures of different chars characterized by variable levogluconan yield. Acid dichromate oxidation is opposed to the levogluconan method: detected mid- to high temperature char BC (>350°C) but not low temperature char (<250°C). Our results indicate that the overlap in the analytical windows of the two methods is limited to the upper limit of the latter.

The study demonstrates that levogluconan can serve as a good qualitative indicator for the presence of char produced under low temperature conditions in soil, sediments, and ultrafine aerosols. Although levogluconan is not a proper quantitative proxy for char BC
Fate of CuO-derived lignin oxidation products during plant combustion: Application to the evaluation of char input to soil organic matter

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ABSTRACT
Three suites of synthetic chars, produced from honey mesquite, cordgrass and loblolly pine under controlled combustion conditions, served as model materials for diverse natural chars originating from combustion of angiosperm, gymnosperm and woody/non-woody plants. The lignin oxidation products (LOPs), quantified using the alkaline cupric oxide (CuO) oxidation method, were used to study the impact of combustion on lignins and their commonly used parameters.

Our results show that combustion can greatly decrease the yield of the eight major lignin phenols (vanillic, syringyl and cinnamyl phenols) with no lignin phenols detected in any synthetic char produced at ≥ 400 °C. With increasing combustion temperature, the value of the syringyl/vanillic phenols ratio (SV) of angiosperm chars initially increased but then declined dramatically when the temperature reached 200–250 °C. The pattern of change may relate to the thermal alteration of the plant cell ultrastructure. The cinnamyl/vanillic phenols ratio value (CV) of a non-woody plant, cordgrass, also showed a similar two-stage change with increasing combustion temperature. Combustion duration also caused a similar effect on the yield and signatures of lignin phenols, showing that the combustion severity (temperature and/or duration) has a great influence on LOP yield and signature. The acid/aldehyde ratio of vanillic phenols ([A]/[Al]) and syringyl phenols ([A]/[Al]) increased with increasing combustion temperature and duration and reached a maximum value at 300–350 °C regardless of plant species. The highly elevated acid/aldehyde ratio value reached in some cases exceeded the reported values of humic and fulvic acids extracted from soils and sediments. Furthermore, the ratio of 3,5-dihydroxybenzonic acid to vanillic phenols ([3,5]/[A]), a soil humification indicator, increased significantly during combustion at 250–350 °C in char samples from all the plant species. Our results imply that changes in LOP signatures in chars can serve as potential indicators of their formation temperature.

Simulations using a two end member mixing model showed that different char samples, with different degrees of lignin alteration, could have a substantial effect on the bimarker signatures of soil organic matter (SOM). The shifts in lignin signatures in SOM vary widely, depending on the SOM characteristics (e.g. soil litter vs. mineral soil) and the proportion of char in the mixture. Overall, the input of high temperature char tends to dilute the lignin signal in SOM and may lead to underestimation of vascular plant OM input to environmental matrices. Our observations demonstrate that, in addition to photochemical degradation, thermal alteration is an important abiotic lignin degradation process.

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The Effect of Using Inquiry and Multiple Representations on Introductory Geology Students' Conceptual Model Development of Coastal Eutrophication

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ABSTRACT

Collegiate introductory Earth science courses are frequently terminal science courses for non-science majors. As such, many instructors have little incentive to support student learning in the sciences. The use of inquiry-based learning (IBL) and multiple representations (e.g., physical models and informatics technology) has been a call for reform in science education and may be a means to reach students in introductory courses. This research tested the pedagogical coupling of IBL and multiple representations to support introductory students' conceptual model development of the complex and dynamic Earth processes, eutrophication, through the evaluation of student drawings and written reports. In this research, participants from three laboratory sections were randomly placed into experimental (IBL and multiple representations, style labs) and control (workbook-style labs) groups. Statistical results indicated significant (p < 0.05) pre-post differences in the conceptual model drawings in only the experimental group, whereas student performance on the reports and drawings were significantly different (p < 0.01) between test groups. These results indicated that the use of IBL and multiple representations had a positive impact on introductory students' conceptual model development of eutrophication.

INTRODUCTION

A principle objective of Earth and environmental education is to achieve scientific literacy among students where they are prepared for future participation in society as informed citizens and are able to make educated decisions about a rapidly changing and complex world (AAAS, 1993; Jimenez-Aleixandre and Perozo-Munos, 2002; NRC, 2000). Miller (1993, 1998) defines scientific literacy as a multidimensional construct which includes understanding of basic scientific vocabulary, the process of the nature of scientific inquiry, and the impact of science and technology on society. However, many introductory science and geoscience courses are generally designed to cover facts, theories, and techniques that do not relate to other fields to deeper thinking and do not support accurate conceptual model development; therefore leading students to develop a naive view that science is an accumulative fact of facts that describe the world (Dori and Hersoritz, 1999; Mathewson, 1962; Sandoval and Reisner, 2003). These student views may ultimately lead to the development of inaccurate conceptual understandings of complex Earth and environmental systems, the nature of science, and affect the ability to make sound decisions and arguments about socio-scientific issues (Bell and Lederman, 2003; Sadler et al., 2004; Zeidler et al., 2005).

Students' ability to understand complexity has become a leading research strand in recent studies (Elburg, 2003; Forrester, 1994; Grotzer, 1992; Kuhn et al., 2000; Kats, 2002; Sell et al., 2000) because most natural systems exhibit characteristics that are complex. These characteristics can include (i) interactions between system components, (ii) changes in system state over space and time, (iii) unpredictable self-organization that generates patterns of structure or patterns and (iv) chaotic behavior (Colucci-Gray et al., 2006; Herbert, 2000; Sell et al., 2000). Eutrophication is an example of a complex Earth process, where excess nutrients (nitrogen and phosphorous) from fertilizers, discharges of human waste, animal production, and combustion of fossil fuels (Nixon, 1990) stimulate the growth of phytoplankton and indirectly the bacteria. Bacterial processes on the seafloor feed upon the sinking phytoplankton and other sources of particulate material (AOM; e.g., phytoplankton, detritus, local pelagic, etc.). This process can ultimately lead to the on-set of bottom water hypoxic conditions in some estuarine regions. Hypoxia, traditionally defined when dissolved oxygen is < 2 mg L$^{-1}$ in the water column, has been reported in approximately 50 places in the world. Benthic-pelagic coupling is frequently important during hypoxic conditions because the anaerobic benthic metabolism quickly dominates as the primary mode of respiration where the production of reduced dissolved species (e.g., H$_2$S and Fe$^{2+}$) in sediment porewaters can either penetrate into the overlying waters, further contributing to the hypoxic event, or precipitate to form a variety of minerals (e.g., Fe-$\text{Sulfo}$; Sell and Morse, 2000). The environmental topic of eutrophication was used in this research study because it is an important socio-scientific issue and consistently occurs in the Gulf of Mexico, which is located less than 100 miles from the university, causing it to be a relevant topic for many of our students.

Solving complex problems, such as eutrophication, requires the development of accurate conceptual models - expressed mental models that can be described as an accurate, reasonable representation of natural phenomena (Greco and Moreira, 2000; Libarkin et al., 2005). A mental model becomes expressed once it is represented or communicated through drawings, symbols, objects, or words. Poor conceptual models of complex environmental systems have led stakeholders...
Velocity structure of upper ocean crust at Ocean Drilling Program Site 1256

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[1] We examine shipboard physical property measurements, wireline logs, and vertical seismic profiles (VSP) from Ocean Drilling Program/Integrated Ocean Drilling Program Hole 1256D in 15 Ma ocean crust formed at superfast spreading rates to investigate lateral and vertical variations in compressional velocity. In general, velocities from all methods agree. Porosity is inversely related to velocity in both the logging and laboratory data. We infer that microfracturing during drilling is minor in the upper 1 km of basement, probably due to connected pores and, thus, low effective stress. The closure of porosity to very low values coincides with the depth below which laboratory velocities diverge from logging velocities. We infer that porosity controls velocity in layer 2, lithostatic pressure controls the thickness of seismic layer 2, and the distribution of flow types determines seismic velocity in the upper 200 m of basement. In the sheeted dikes, changes in physical properties, mineralogy, and chemistry define clusters of dikes.
Deep-tow magnetic anomaly study of the Pacific Jurassic Quiet Zone and implications for the geomagnetic polarity reversal timescale and geomagnetic field behavior

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[1] The Jurassic Quiet Zone (QZ) is a region of low-amplitude magnetic anomalies whose distinctive character may be related to geomagnetic field behavior. We collected deep-tow magnetic profiles in Pigafetta Basin (western Pacific) where previous deep-tow data partially covered the QZ sequence. Our goals were to extend the survey through the QZ, examine anomaly correlations, and refine a preliminary geomagnetic polarity timescale (GPTS) model. We collected a series of closely spaced profiles over anomaly M34 and Ocean Drilling Program Hole 801C to examine anomaly correlation in detail, one profile in between previous profiles, and two long profiles extending the survey deeper into the QZ. Anomaly features can be readily correlated except in a region of low-amplitude, short-wavelength anomalies in the middle of the survey area (“low-amplitude zone” or LAZ). The small multiprofile surveys demonstrate anomaly linearity, implying that surrounding anomalies are also linear and likely result from crustal recording of geomagnetic field changes. We constructed a GPTS model assuming that most anomalies result from polarity reversals. The polarity timescale is similar to the polarity sequences from previous studies, but its global significance is uncertain because of problems correlating anomalies in the LAZ and the ambiguous nature of the small QZ anomalies. Overall anomaly amplitudes decrease with age into the LAZ and then increases again, implying low geomagnetic field strength, perhaps related to a rapidly reversing field. Other factors that may contribute to the LAZ are interference of anomalies over narrow, crustal polarity zones and poorly understood local tectonic complexities.


1. Introduction

[5] The Jurassic period appears to be a time of unusual geomagnetic behavior with low-amplitude, difficult-to-correlate marine magnetic anomalies. The unique, low-amplitude character of the magnetic anomalies has invoked discussion about the nature of the Jurassic magnetic field. It was once suggested that this Jurassic “Quiet Zone” (QZ) reflects a period during which the geomagnetic field did not reverse, analogous to the Cretaceous Quiet Zone (e.g., Hésmer and Hay, 1967; Larson and Pitman, 1972; Hayes and Rabinowitz, 1975; Barnett and Keen, 1976). Contemporaneous land magnetostratigraphic data contain many geomagnetic field reversals (Steiner, 1986; Ogg et al., 1984; Steiner et al., 1985; Steiner et al., 1987; Ogg et al., 1991; Ogg and Gutoski, 1995), suggesting that the QZ is instead a period of rapid polarity reversals. Whether the small-amplitude QZ anomalies represent actual geomagnetic field reversals or intensity fluctuations is a debate with fundamental implications for the interpretation of the geomagnetic polarity reversal timescale (GPTS) and implied reversal rates, which may have been higher than at any time in recorded geomagnetic history (e.g., Cande and Kent, 1992a, 1992b; Sager et al., 1998; Roest et al., 2002; Bowles et al., 2003; Tivey et al., 2006).

[1] The QZ encompasses middle to Late Jurassic age seafloor in both Pacific and Atlantic oceans where magnetic lineations are reduced in amplitude to the point of incoherence. Over the years, the age of the young edge of the QZ has been pushed farther back in time as small, correlatable anomalies were recognized deeper in the anomalous zone (e.g., Larson and Hilde, 1975; Cande et al., 1978; Handschumacher et al., 1987; Sager et al., 1998). Although M29 is the oldest anomaly accepted in most GPTS models (Channell et al., 1995), aeromagnetic and deep-tow magnetic data show many older anomalies in the Pacific QZ (Handschumacher et al., 1987; Sager et al., 1998). These older anomalies are more apparent in aeromagnetic and deep-tow data because these techniques...
Non-Darcian Flow Toward a Finite-Diameter Vertical Well in a Confined Aquifer+a

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ABSTRACT

Non-Darcian radial flow toward a finite-diameter, fully penetrating well in a confined aquifer was analyzed on the basis of the Inhesh equation with consideration of the wellbore storage effect. We derived semi-analytical solutions of drawdown by using the Boltzmann transform, and obtained approximate analytical solutions of the drawdown at early and late times. MATLAB programs were developed to facilitate computation of the semi-analytical solutions. The turbulence factor ν which was directly related to the pumping rate appeared to have negligible influence upon the wellbore well function at early times, but imposed significant influence at intermediate and late times. However, the turbulence factor ν imposed non-negligible influence upon the aquifer well function during the entire pumping period, provided that the observation point was not sufficiently close to the wellbores. Sensitivity analysis indicated that the power index n in the Inhesh equation had less influence on the type curves at the face of the pumping wellbores, but had much greater influence upon the well function in the aquifer. As the ν value increased, the drawdown in the aquifer decreased at early times and increased at late times. The Boltzmann transformation could only be used in an approximate sense for radial non-Darcian flow problems. This approximation would provide accurate solutions at early times, and introduce small but consistent discrepancies at intermediate and late times for the wellbore well function.

Key Words: Finite-diameter well, non-Darcian flow, type curve, well function, wellbore storage


Hydraulics of flow to finite-diameter wells has been studied for several decades (Cimea, 2001; Female, 1977; Lai and Su, 1974; Patel and Minaara, 1983; Papadopulos and Cooper, 1967; Sen, 1982). Most of those studies were based on a presumption that flow was Darcian. However, under certain circumstances, flow can be non-Darcian, manifested by a nonlinear relationship between the specific discharge and the hydraulic gradient.

Non-Darcian flow has been observed in numerous laboratory and field experiments (e.g., Soni et al., 1978; Skjetne et al., 1999; Sen, 1999; Hill and Koch, 2002; Chen et al., 2003; Qian et al., 2000), and non-Darcian flow to a well primarily occurs in highly permeable or fractured media (e.g., Venkataraman and Ray, 1995; Fourar et al., 2004; Fourar et al., 2005; Panfilov and Fourar, 2000). For instance, Kohl et al. (1997) have conducted hydraulic tests at the hot dry rock (HDR) test site in South of France and have found strong evidence of non-Darcian flow in fractured rocks. Lee and Lee (1999) have emphasized the importance of including non-Darcian flow in interpreting repeated pumping and slug tests in a fractured porous aquifer in Korea. Yanada et al. (2006) have developed a field method for measuring the hydraulic permeability in a gravel bed by using the packer test and derived an equation under any type of flow condition including turbulent flow. Auriault et al. (2007) have investigated high velocity flow in heterogeneous media based on the Forchheimer equation. It has been shown that using Darcy's

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Two-region non-Darcian flow toward a well in a confined aquifer

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Abstract

We have derived an analytical solution for two-region flow toward a well in a confined aquifer based on a linearization method. The two-region flow includes Izhbash non-Darcian flow near the well and Darcian flow in the rest of the aquifer. The wellbore storage is also considered. The type curves in the non-Darcian and Darcian flow domains are obtained by a numerical Laplace inversion method incorporated in MATLAB programs. We have compared our results with the one-region Darcian flow model (Theis). Our solutions agree with those of Sen [Sen Z. Type curves for two-region well flow. J Hydrol Eng 1988;11(12):1461–84] which were obtained using the Boltzmann transform at late times for fully turbulent flow, while some difference has been found at early and moderate times. We have defined a dimensionless non-Darcian hydraulic conductivity term which is shown to be a key parameter for analyzing the two-region flow. A smaller dimensionless non-Darcian hydraulic conductivity results in a larger drawdown in the non-Darcian flow region at late times. However, the dimensionless non-Darcian hydraulic conductivity does not affect the slope of the dimensionless drawdown versus the logarithmic dimensionless time in the non-Darcian flow region at late time. The dimensionless non-Darcian hydraulic conductivity does not affect the late time drawdown in the Darcian flow region.

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Keywords: Non-Darcian; Two-region; Type curve; Power law; Laplace transform; Analytical solution; Linearization method

1. Introduction

Darcy’s law has been the foundation for studying porous media flow for more than 150 years. However, given the vast complexity of porous media structures, it is not surprising to find that this law actually does not work under some circumstances. Deviation from the linear form of Darcy’s law, or the so-called non-Darcian flow has caught the attention of scientists and engineers for many decades (e.g. \cite{1,8,12,14,23,32,40,42}). However, because of the nonlinear nature of the problem, many aspects of non-Darcian flow are still not fully understood.

Non-Darcian flow often occurs at very low \cite{36} or very high hydraulic gradients\cite{2,4,20,43}. For instance, Tavenas et al. \cite{35} found that Darcy’s law is only valid in soft clays for hydraulic gradients ranging from 0.1 to 50. As Darcy’s law becomes invalid in some cases, many formulae have been proposed to quantify the relationship between the hydraulic gradient and the specific discharge for non-Darcian flow (e.g. \cite{10,11,16,31}). The most commonly used are the Forchheimer equation and the Izhbash equation. The Forchheimer equation states that the hydraulic gradient is a second-order polynomial function of the specific discharge; whereas the Izhbash equation states that the hydraulic gradient is a power function of the specific discharge. Many studies have indicated that both equations can describe non-Darcian flow quite well.
An analytical solution for non-Darcian flow in a confined aquifer using the power law function

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Abstract

We have developed a new method to analyze the power law based non-Darcian flow toward a well in a confined aquifer with and without wellbore storage. This method is based on a combination of the linearization approximation of the non-Darcian flow equation and the Laplace transform. Analytical solutions of steady-state and late time drawdowns are obtained. Semi-analytical solutions of the drawdowns at any distance and time are computed by using the Stehfest numerical inverse Laplace transform. The results of this study agree perfectly with previous Theis solution for an infinite-sloped well and with the Papadopoulos and Cooper's solution for a finite-diameter well under the special case of Darcian flow. The Boltzmann transform, which is commonly employed for solving non-Darcian flow problem in the field study, is problematic for studying radial non-Darcian flow. Comparison of drawdowns obtained by our proposed method and the Boltzmann transform method suggest that the Boltzmann transform method differs from the linearization method at early and moderate times, and it yields similar results as the linearization method at late times. If the power index n and the quasi hydraulic conductivity k get larger, drawdowns at late times will become less, regardless of the wellbore storage. When n is larger, flow approaches steady state earlier. The drawdown at steady state is approximately proportional to r^{-n}, where r is the radial distance from the sinking well. The late time drawdown is a superposition of the steady-state solution and a negative time-dependent term that is proportional to r^{1-n+3-n} where r is the time.

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Keywords: Non-Darcian flow; Power law; Laplace transform; Linearization method

1. Introduction

Scientists and engineers have been fascinated with non-Darcian flow for more than one hundred years [8] and there are still plenty of unanswered questions. Among many difficulties encountered in dealing with non-Darcian flow, two of them are notable. One of them is to adequately characterize non-Darcian flow using physically measurable parameters. The other is to find a robust mathematical tool to solve the non-Darcian flow governing equation. Non-Darcian flow can arise from a number of different ways. For flow at low rates in fine-grained media such as clay and silt aquifers, the non-Darcian flow may be attributed to the electro-chemical surface effect between the fluid and the solid, and is named pre-linear flow [32,36]. The pre-linear flow has also been extensively investigated in the petroleum engineering [35,5]. For flow at high rates in coarse grained and fractured media, or near pumping wells, the non-Darcian flow may be caused by the inertial effect and the onset of turbulent flow, and is subsequently named post-linear flow [1,4,24,36,39].

Many formulas have been proposed to quantify the relationship between the hydraulic gradient and the specific...
Non-Darcian flow to a well in an aquifer–aquitard system

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1. Introduction

Groundwater flow in leaky aquifers has been investigated for decades (e.g., [13-15,24,26,41,57]). The first mathematical model for flow to a well in leaky aquifers was developed by Harbaugh and Jacob [13]. In that study, they presented an analytical solution for transient flow to a well in leaky aquifers based on a series of simplified assumptions, e.g., flow in aquitard is vertical, pumping rate of well is constant, storage of aquitard is negligible, etc. This solution has been extended by Harbaugh [14] to consider flow to a constant-head pumping well, and by Harbaugh [15] to consider the storage of aquitard. Recently, many researches about the hydraulics in leaky aquifers have been done (e.g., [1,16,22,23,30,54,55]). For instance, Li and Neuman [23] investigated flow to a well in a five-layer system, and validated their solution with a pumping test in the Oxnard Basin, California, USA. Hunt and Massmann [18] presented an analytical solution for flow to a trench in a leaky aquifer, and the solution can be used to evaluate the permeability and the leak parameter. Yeh et al. [54] used global optimization methods to determine the parameters for the leaky aquifers. Zhang and Tan [55] have provided some practical useful solutions for estimating the rate and volume of water leaked through a semi-confined layer within any given radial distance from the pumping well. All of these studies are based on the assumption that flow is Darcian. However, under some circumstances, flow can be non-Darcian because of the high velocities near a pumping well [2,37]. For example, if the pumping rate of the well is sufficiently large, which will result in a relatively
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Centimeter-scale characterization of biogeochemical gradients at a wetland–aquifer interface using capillary electrophoresis

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Abstract

Steep biogeochemical gradients were measured at mixing interfaces in a wetland–aquifer system impacted by landfill leachate in Norman, Oklahoma. The system lies within a reworked alluvial plain and is characterized by layered low hydraulic conductivity wetland sediments interbedded with sandy aquifer material. Using cm-scale passive diffusion samplers, "peepers", water samples were collected in a depth profile to span interfaces between surface water and a sequence of deeper sedimentary layers. Geochemical indicators including electron acceptors, low-molecular weight organic acids, base cations, and NH4+ were analyzed by capillary electrophoresis (CE) and field techniques to maximize the small sample volumes available from the centimeter-scale peepers. Steep concentration gradients of biogeochemical indicators were observed at various interfaces including those created at sedimentary boundaries and boundaries created by heterogeneities in organic C and available electron acceptors. At the sediment–water interface, chemical profiles with depth suggest that SO42− and Fe reduction dominate driven by inputs of organic C from the wetland and availability of electron acceptors. Deeper in the sediments (not associated with a lithologic boundary), a steep gradient of organic acids (c. 8.8 mM) and NH4+ (maximum 36 mM) is observed due to a localized source of organic matter coupled with the lack of electron acceptor inputs. These findings highlight the importance of quantifying the redox reactions occurring in small interface zones and assessing their role in biogeochemical cycling at the system scale.

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1. Introduction

To understand and predict the fate and transport of numerous chemical species, including nutrients and contaminants, it is important to identify the most active zones of biogeochemical cycling within a system. It has been proposed that in natural systems, zones with steep biogeochemical gradients may be areas of increased microbial activity (Kappler et al., 2003). Microbial activity is enhanced when concentration gradients of limiting electron acceptors and/or electron donors come in contact, such as in the transition zones between environments of differing redox potential (Koretsky et al., 2003; Llobet-Brossa et al., 2002; McMahon and Chapelle, 1991; Sass et al., 2002; Ulrich et al., 1996). Although the potential importance of transition zones is widely accepted, characterization is challenging because chemical and microbiological...
Non-linear inversion of controlled source multi-receiver electromagnetic induction data for unexploded ordnance using a continuation method

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Abstract

This work adopts a continuation approach, based on path tracking in model space, to solve the non-linear least-squares problem for discrimination of unexploded ordnance (UXO) using multi-receiver electromagnetic induction (EMI) data. The forward model corresponds to a stretched-exponential decay of eddy currents induced in a magnetic spheroid. We formulate an over-determined, or under-parametrized, inverse problem. An example using synthetic multi-receiver EMI responses illustrates the efficiency of the method. The fast inversion of actual field multi-receiver EMI responses of inert, buried ordnance is also shown. Software based on the continuation method could be installed within a multi-receiver EMI sensor and used for near-real-time UXO decision-making purposes without the need for a highly-trained operator.

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Keywords: Near-surface geophysics; Electromagnetic induction; Data processing; Inversion; Tomography; Unexploded ordnance

1. Introduction

Unexploded ordnance (UXO) detection, discrimination and removal represents a priority environmental and geotechnical problem in many regions of the world including Central America, Africa, and Asia. A common factor in cleanup operations is the huge final cost per UXO removed, mainly associated with unnecessary digging operations. The probability of UXO detection on documented test sites can exceed 90% in carefully executed geophysical surveys; however, despite recent advances in geophysical technologies and signal processing algorithms the false alarm rates remain unacceptably high.

One of the challenges faced by geophysicists during cleanup operations is development of improved sensors and algorithms capable of recording target responses, isolating them from geological noise, and processing them in near-real-time without highly-trained operator intervention. A key step during data processing is model dimension reduction. The most widely-used dimension reduction method is inversion of the data using a low-dimensional forward model that sufficiently describes the target response. Under the requirements of UXO cleaning operations, the adopted inversion method must be fast, robust, and almost independent of the subjective bias and training of the instrument operator. The inversion should provide parameters whose values are invariant with
Temporal variability of uranium concentrations and $^{234}$U/$^{238}$U activity ratios in the Mississippi river and its tributaries

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Abstract

$^{234}$U/$^{238}$U activity ratios and total dissolved uranium concentrations in the Lower Mississippi River at New Orleans, LA have been analyzed on a bi-weekly basis over 2003–2004. During this time period, the range in $^{234}$U/$^{238}$U activity ratios is approximately 17% (from 1.24 to 1.47), while uranium concentrations span an even greater range of 30% (0.28 to 1.33 ppb). There is no correlation between uranium activity ratio and discharge, and only a very weak correlation between uranium concentration and discharge. In order to examine the cause of the substantial variability in the lower river concentrations and $^{234}$U/$^{238}$U activity ratios, we sampled the four major tributaries of the Mississippi River (Ohio, Missouri, Upper Mississippi, and Arkansas Rivers). Each river was sampled four times, each time representing a unique discharge season. In general, lithological and climatological parameters in the tributary sub-basins exert the greatest control on Lower Mississippi River uranium concentration and isotope signatures. These parameters may also be influenced by groundwater infiltration below the confinements of the major tributaries.

Our temporal analysis suggests that if one were to estimate Mississippi River uranium fluxes to the ocean based on single-point sampling during 2003–2004, significant over- or under-estimations of these values would ensue. Our two year average Mississippi River uranium flux values suggest that previous best estimates of the contribution of Mississippi River uranium to the global average riverine $^{234}$U/$^{238}$U activity ratio are too high by 36%. If other major world rivers are as poorly constrained with respect to uranium systematics as the Mississippi River, then the global average riverine U flux and $^{234}$U/$^{238}$U activity ratio need to be revised.

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Keywords: Mississippi river; Uranium isotope ratio; Temporal variability; Tributary source; Global riverine uranium flux

1. Introduction

Uranium has a long residence time in the ocean (~400 ka; Chen et al., 1986), and behaves conservatively underoxic conditions. As a consequence, the uranium concentration of seawater is relatively constant (~3.2 ppb; Chen et al., 1986). Riverine input is the major source of dissolved uranium to the global ocean (average riverine uranium ~ 0.31 ppb; e.g., Palmer and Edmond, 1993; Henderson, 2002; Dunk et al., 2002). This uranium is not in isotopic secular equilibrium. Indeed, the global riverine $^{234}$U/$^{238}$U activity ratio is estimated to be greater than 1 (~1.17; Chabaux et al., 2003), because $^{234}$U is preferentially leached from α-recoil damage sites in rocks and sediments during weathering. Since rivers...
Bitumen Surface Energy Characterization by Inverse Gas Chromatography

ABSTRACT: Modern surface energy theory has been identified in recent years as an attractive tool by which to select compatible bitumen-aggregate combinations. In addition, this technique offers the opportunity to quantitatively assess moisture susceptibility of these material combinations. The success of implementing this technology depends on the availability of techniques that allow efficient and reliable surface energy characterization of the materials under consideration. This paper focuses on bitumen surface energy characterization employing inverse gas chromatography (IGC). The authors report column preparation and test methodologies, and provide a precision statement for this technique. Analysis procedures and results presented demonstrate successful application of this technique with modern thermodynamic theory to acquire bitumen surface energy components. The technique allows testing at different temperatures and results are in agreement with conceptual and theoretical expectations. Surface energy values derived from IGC compare reasonably well with mechanical surface tension values from the literature. Results suggest that surface energies do not vary considerably between different bitumen types, indicative of the controlling role of aggregate type in bitumen-aggregate adhesion.

KEYWORDS: bitumen, adhesion, bitumen-aggregate adhesion, surface energy, surface tension, inverse gas chromatography

Introduction

Adhesion between bitumen and aggregate is fundamentally responsible for the integrity of asphalt mixes under dynamic wheel loads and environmental influences such as moisture fluctuation. Researchers in the first half of the 20th century recognized the importance of surface tension of the materials involved, but quantitative application of these numbers remained a challenge. In 1964, Fowkes [1] introduced concepts that stimulate a different approach to the application of physical chemistry to adhesion science. The theory by van Oss et al. [2] is widely applied and expresses the relationship between Gibbs free energy of adhesion (ΔG^0), work of adhesion (W), and surface energy (σ) in units mJ/m^2, as follows:

$$-ΔG^0 = W - 2 \sqrt{\frac{W}{\eta_i \eta_j}} + 2 \sqrt{\frac{W}{\eta_i^2 \eta_j^2}} + 2 \sqrt{\frac{W}{\eta_i \eta_j^2}}$$

where i and j represent two materials that form an adhesive bond. According to Fowkes [1] total surface energy (equal to surface tension for liquids) is comprised of components that represent the important forces responsible for the formation of adhesive bonds at an interface. In the theory presented above, $\eta_i$ is the Lifshitz-van der Waals component, $\eta$ is the acid (or electron acceptor) component, and $\gamma$ is the base (or electron donor) component. The Lifshitz-van der Waals component represents nonpolar species (such as alkanes, paraffins, or aliphatic compounds in bitumen) that interact through nonpolar van der Waals interactions, while the acid and base components represent polar compounds associated with specific interactions. Hefer et al. [3] describe theories and mechanisms responsible for bitumen-aggregate adhesion in more detail.

Equation 1 implies that any technique capable of “measuring” the free energy of adhesion ($\Delta G^0$) can be used to resolve the surface energy components of the “unknown” material under consideration. Elphingstone [4] and Cheng et al. [5] used the Wilhelmy plate technique to calculate $\Delta G^0$ from contact angles of different liquids in contact with bitumen. Li [6] and Cheng et al. [5] used a static gravimetric gas sorption technique to calculate $\Delta G^0$ from equilibrium spreading pressures of different probe gases in contact with aggregate. In this paper, inverse gas chromatography (IGC) is proposed as a candidate technique for surface energy characterization of bitumen. Simplicity, convenience of experimentation, and control of test conditions has inspired the use of this technique in many industries. This approach has proven to be effective in characterizing surface energies of various materials such as polymers, fibers, minerals, and pigments [7].

This paper introduces inverse gas chromatography and provides a detailed methodology for column preparation and testing. An analysis procedure used to calculate surface energy components from the measured parameters in accordance with the theory developed by van Oss and his colleagues is presented. Finally, bitumen surface energies are compared to mechanical surface tension data obtained from the literature.

Inverse Gas Chromatography

Analytical chromatography is a simple technique used to separate a mixture into its constituents. When an inert gas (carrier gas) carries a gas mixture through a chromatographic column, each compound interacts differently with a known material in the column (stationary phase) that results in different travel times (retention times) for different constituent compounds (mobile phase) through the column. Inverse gas chromatography differs from this, more conventional, analytical chromatography in that the stationary phase is the “unknown” material under investigation; while different probe
Capture zone between two streams

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Summary We have investigated stream–aquifer interaction with a single pumping well in an aquifer bounded by two parallel nearby streams. This study presents steady-state semi-analytical solutions to calculate the fraction of water withdrawal from two streams. Potential theory is used to describe the capture zone between two streams when low-permeability streambeds are not present. Steady-state flow equations in the aquifer and two streambeds are solved following rigorous mass balance requirements if low-permeability streambeds are present. When the low-permeability streambeds are not present and the regional flow exists between two streams, this study finds that the maximal capture size without extracting water from the down-gradient stream decreases with the normalized well location in an approximately linear fashion. Furthermore, the normalized flux from the up-gradient stream decreases with the normalized well location faster than the linear fashion. When the low-permeability streambeds exist and the regional flow is neglected, the normalized flux across either streambed varies with the normalized well location in a linear function. Furthermore, the magnitude of the slope of that function is nearly unity when the hydraulic conductance ratio of the two streambeds is one and is less than unity when the hydraulic conductance ratio of the two streambeds is either greater or smaller than one. When the normalized well location with equal fluxes from two streams versus the hydraulic conductance ratio of the two streambeds are plotted semi-logarithmically, we observed a segmented curve including a steep segment at the beginning, followed by a flat segment, and a final steep segment.

Introduction

A capture zone refers to an aquifer volume in which water can be extracted by one or multiple pumping wells penet-
Evaluation of sulfate reduction at experimentally induced mixing interfaces using small-scale push–pull tests in an aquifer–wetland system

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Available online 21 June 2007

Abstract

This paper presents small-scale push–pull tests designed to evaluate the kinetic controls on SO\textsubscript{4}\textsuperscript{2-} reduction in situ at mixing interfaces between a wetland and aquifer impacted by landfill leachate at the Norman Landfill research site, Norman, OK. Quantifying the rates of redox reactions initiated at interfaces is of great interest because interfaces have been shown to be zones of increased biogeochemical transformations and thus may play an important role in natural attenuation. To mimic the aquifer–wetland interface and evaluate reaction rates, SO\textsubscript{4}\textsuperscript{2-}-rich anaerobic aquifer water (~104 mg/L SO\textsubscript{4}\textsuperscript{2-}) was introduced into SO\textsubscript{4}\textsuperscript{2-}-depleted wetland porewater via push–pull tests. Results showed SO\textsubscript{4}\textsuperscript{2-} reduction was stimulated by the mixing of these waters and first-order rate coefficients were comparable to those measured in other push–pull studies. However, rate data were complex involving either multiple first-order rate coefficients or a more complex rate order. In addition, a lag phase was observed prior to SO\textsubscript{4}\textsuperscript{2-} reduction that persisted until the mixing interface between test solution and native water was recovered, irrespective of temporal or spatial constraint. The lag phase was not eliminated by the addition of electron donor (acetate) to the injected test solution. Subsequent push–pull tests designed to elucidate the nature of the lag phase support the importance of the mixing interface in controlling terminal electron accepting processes. These data suggest redox reactions may occur rapidly at the mixing interface between injected and native waters but not in the injected bulk water mass. Under these circumstances, push–pull test data should be evaluated to ensure the apparent rate is actually a function of time and that complexities in rate data be considered.

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1. Introduction

In subsurface aqueous systems, it is well recognized that interfaces between distinct water masses may be the most active zones of biogeochemical activity (Kappler et al., 2005); however, quantification of the complex suite of reactions initiated at these interfaces has been poorly documented. Steep geochmical gradients have been observed where waters with differing chemical/physical properties come in contact (e.g., the interface zone surrounding a contaminant plume or an aquifer–wetland interface) (Vroblesky and Chapelle, 1994; McGuire...
REPLY

Reply to the comments of Dr. K.R. Rushton on "Steady flow to a horizontal drain in an unconfined aquifer with variable thickness."

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We thank Dr. Rushton for his interest and comments on our paper. In the following, we would like to address a number of issues associated with those comments, which can be summarized into the following items:

1. "The fixed heads, AB and CD, are equivalent to vertical channels, full of water, fully penetrating to the base of the aquifer, ... This is an artificial problem since it is physically unlikely that fully penetrating channels would be constructed at about 20 m intervals with a horizontal drain midway between these channels."

2. "For large horizontal drains and/or low recharge, the water table may intersect the drain but for most practical situations, even when the drain is only running partially full, the water table is above the drain, fig. (1b)."

3. "It would be of interest to know whether authors can include recharge in their analytical element approach and also whether they can represent a drain as an internal boundary."

Our reply to these three comments is as follows: Reply to comment 1: First, Dr. Rushton has misunderstood the unit used in our paper. We have only used dimensionless terms in our analysis and have not discussed a "20 m interval". Table 1 of Kompani-Zare and Zhan (2006) has defined all the dimensionless terms used in the paper. In particular, the dimensionless horizontal distance $x_d$ is defined as the actual horizontal distance over the drain elevation above the impermeable boundary. Therefore, if the lateral boundary is at $x_d = 10$ from the drain, the actual distance is 10 times the distance of the drain elevation from the bottom boundary, and this is often a large value provided that the drain is not too close to the bottom boundary. Nevertheless, our point is to allow the lateral boundaries to be sufficiently far from the drain to minimize their influence upon flow near the drain. As an example, we use constant-head lateral boundaries in this study.
An improved mesh generation scheme for the wavefront construction method

Kyoung Jin Lee\textsuperscript{1} and Richard L. Gibson Jr.\textsuperscript{2}

\textbf{ABSTRACT}

Wavefront construction is an effective tool for the rapid calculation of ray fields in anisotropic media. The method explicitly tracks the propagation of a wavefront through a model, mapping it to a computational mesh that is interpolated when accuracy criteria are violated. Takeoff angles are used to define the initial ray directions, but uniform sampling in the two angles leads to oversampling of the ray field in the direction of the axes. Such sampling can lead to numerical instability associated with vanishing derivatives with respect to the azimuthal angle. We suggest a new wavefront mesh definition using the cubed-sphere mesh, which is a coordinate system used to solve partial differential equations in spherical geometries. When using this mesh, ray directions are assigned by mapping points on a regular discretization of the faces of a cube surrounding the source to corresponding rays. This scheme produces nearly uniform distribution of rays with minimal effort and using the cubed-sphere coordinates as ray parameters to calculate partial derivatives completely eliminates the singularities that occur when takeoff angles are used as ray parameters. Numerical results for quantities related to seismic amplitudes confirm that this new mesh does provide more stable and reliable results.

\textbf{INTRODUCTION}

Ray methods are useful for a number of applications ranging from high-speed forward modeling to inversion and imaging algorithms requiring many repeated simulations (Cerveny, 2001). Classical implementations have some significant shortcomings, because shooting-ray approaches can become very inefficient as model complexity increases. Some recent alternatives apply direct solution of the eikonal equations using finite differences, graph theoretical, or other approaches to rapidly compute traveltimes throughout the volume of a regular discretization of an earth model (Vidale, 1990; Moser, 1991; Van Trier and Symes, 1991; Zhang and Toksöz, 1998; Kim, 2002). However, these methods generally compute results only for the first arrival and have difficulty computing amplitudes. Recent developments have continued to improve such methods, providing more reliable results for amplitudes, though some of the algorithms become less efficient in the case of multiple arrivals or smaller numbers of source points (Symes, 1998; Fomel and Sethian, 2002; Qian and Symes, 2002; Buik and Kustner, 2004). There are, however, some new developments that can evaluate multipath solutions for acoustic media, though they have not been applied directly to geophysical applications (Cockburn et al., 2005; Ying and Candès, 2006).

In contrast, wavefront construction methods (WFC) produce traveltimes and amplitudes for multiple arrivals and for amplitudes, and recent publications describe algorithms for both isotropic and anisotropic media (Vinje et al., 1993; Lambard et al., 1996; Vinje et al., 1999a; Leidner et al., 1996; Thierry et al., 1999; Vinje et al., 1999; Gibson, 2000; Mispel and Williamson, 2001; Fomel and Sethian, 2002; Mulder and ten Kroode, 2002; Kaschwich and Gajewski, 2003; Gibson et al., 2005). They accelerate computation in two ways. First, the calculation begins with a sparse set of rays near the source and only computes other rays starting at larger distances away from the source where they are inserted into a mesh, tracking the propagation of a wavefront. Because calculating a ray is the most expensive part of the computation, minimizing the length and number of rays produces significant improvements in speed. Second, because the method explicitly tracks the geometry of the wavefront, identifying multiple arrivals is simpler and more efficient than approaches considering only individual rays.

However, one important challenge is to specify the initial set of rays that defines the first wavefront mesh. The most natural approach may be simply to trace rays at even increments of the azimuthal and
Deglacial changes in dust flux in the eastern equatorial Pacific

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Abstract

Atmospheric dust levels may play important roles in feedbacks linking continental source areas, tropical convection, marine productivity, and global climate. These feedbacks appear to be particularly significant in the tropical Pacific, where variations in local convection and productivity have been demonstrated to have impacts on climate at higher latitudes. Modeling of past dust levels and related feedbacks has been limited, however, by a paucity of observational data. In this study we present a temporal and spatial survey of dust fluxes to the eastern equatorial Pacific over the past 330kyr. Glacial and Holocene fluxes of 230Th, a proxy for continental material, were calculated by normalization to 231Pa from a north–south transect of cores along 110°W between 2°S and 7°N (GDP sites 848–853). Fluxes were 30–100% higher during the last glacial, suggesting increased dustiness in both hemispheres during the glacial period. In both time periods, dust fluxes decrease towards the south, reflecting scavenging of Northern Hemisphere dust by precipitation at the ITZC. The Holocene modified dust flux gradient between 7°N and 3°S; it is characterized by a steep drop in dust levels at the southern edge of the modern range of the ITZC, while the gradient is shallower and more nearly linear during the last glacial. This change may indicate that the glacial ITZC in this region was a less effective barrier to interhemispheric dust transport, most likely due to a decrease in convective intensity and precipitation during the last glacial; alternatively, the change in gradient may be explained by increased variability in the location of the glacial ITZC. Our data do not appear to require a mean southerly displacement of the glacial ITZC, as suggested by the results of other studies.

Keywords: dust flux; eastern equatorial Pacific; deglacial; 230Th-profiling; ITZC; GDP Leg 118

1. Introduction

Concentrations of mineral aerosol (dust) may form an important link in feedbacks connecting continental conditions and global climate. Models of Last Glacial Maximum (LGM; ~19–23 ka) conditions suggest that increased dust levels contributed to cooling in the tropics by increasing albedo, leading to a change in tropical radiative forcing that may have been similar in magnitude (~3 to ~4 W m⁻²) to the effect of low atmospheric pCO₂ at the time [1]. Dust-related radiative forcing may have significantly diminished the intensity...
Ramp initiation and spacing in a homogeneous thrust wedge

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Received 15 December 2004; revised 19 July 2006; accepted 3 November 2006; published 26 May 2007.

Fold-and-thrust belts grow largely through sequential initiation of thrust faults and subsequent motion on them from hinterland to foreland, i.e., away from the plate boundary. While perturbations in basal geometry, stratigraphy, excess fluid pressure, folding, and surface slope have all been suggested as mechanisms for thrust ramp nucleation, we show that preexisting inhomogeneities are not necessary. We present a mechanically homogeneous finite element wedge model to assess the effects of variations in yield stress, dilatation angle, and basal friction angle on foreland fold-and-thrust belt evolution. Computer experiments produce a broad foreland dipping plastic strain band that marks the topographic inflection produced by the previous ramp. This band migrates toward the rigid base, where the plastic strain is preferentially concentrated in a thrust ramp. Subsequent ramps develop toward the foreland in a self-similar fashion. The ramp formation process is systematic. Ramps form at the same location with respect to the wedge origin regardless of significant variations in yield stress, dilatation angle, or basal friction. However, the backstop displacement required to initiate a new ramp is dependent on these variables. We conclude that the wedge geometry is the primary factor in determining both thrust ramp location and spacing. Syntectonic erosion and deposition, or any other process that changes wedge geometry, may in some cases control the location of thrust ramps.


1. Introduction

Fold-and-thrust belts grow through sequential stacking of thrust sheets from the hinterland to the foreland of a mountain belt [Armstrong and Oriol, 1965; Sally et al., 1966; Dahlstrom, 1970; Wiltschko and Dorr, 1983; Jordan et al., 1993]. Each thrust sheet rides on a basal fault that at one time formed a new ramp at the front of the previous wedge [e.g., Armstrong and Oriol, 1965; Wiltschko and Dorr, 1983]. The systematic initiation of ramp development [Panian and Wiltschko, 2004] controls ramp spacing. In small regions, the spacing may be constant such as the Sawtooth Mountains of Montana [Watkinson and Patton, 2000; Mudge, 1982]. In larger thrust belts, ramp spacing decreases toward the foreland in a remarkably consistent fashion (Figure 1).

There is no consensus as to the origin of this regular spacing. The key question is why a particular ramp forms where it does. Previous basement topography has been suggested [Wiltschko and Eastman, 1982; Kapp, 1985] based on observations within the central Appalacians and central Wyoming segment of the Idaho-Wyoming-Utah (IWU) thrust belt [see e.g., Jacobsen and Kane, 1975; Kraig et al., 1987]. However, in other fold-and-thrust belts (e.g., Alberta foothills, northern Wyoming segment of the IWU thrust belt, Tennessee segment of the southern Appalachians) no link with basement is obvious on available seismic data [e.g., Bally et al., 1966; Dixon, 1981; Lanmon, 1982; Harris and Milici, 1977]. Stratigraphic changes, laterally or vertically, are invoked by some workers [Bombrall, 1986; Platt, 1986], although see Woodward [1988]. Cello and Nuti [1988] proposed that elevated fluid pressures were responsible implying that ramp spacing is roughly proportional to the depth of the decollement. This prediction is not supported by data from these thrust belts where depth to detachment is well known [e.g., Dixon, 1981]. Also, precursory folding [Dahlstrom, 1970; Goff et al., 1996] and the mechanical influence of topography [Panian and Pilant, 1990; Goff and Wiltschko, 1992] have been considered as mechanisms; the models of Goff and Wiltschko [1992] suggest that a ramp initiates near the model surface approximately in the toe area of the overriding thrust sheet. Conversely, the model of Panian and Pilant [1990] suggests that a new ramp initiates within the decollement beneath the toe of the existing ramp before propagating toward the surface.

We investigate ramp initiation and thrust sheet spacing in a wedge without preexisting inhomogeneities; in a subsequent paper we consider a layered wedge. We have followed the spirit of the mechanical modeling approach of Mekel and Walters [1993], Banimichon and Charlier [1996], Sonni and Fauri [1997], and Gerbault et al. [1998]. Like their models, we have constructed a model that incorporates

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A 28-ka history of sea surface temperature, primary productivity and planktonic community variability in the western Arabian Sea

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[1] Uranium series radionuclides and organic biomarkers, which represent major groups of planktonic organisms, were measured in western Arabian Sea sediments that span the past 28 ka. Variability in the past strength of the southwest and northeast monsoons and its influence on primary productivity, sea surface temperature (SST), and planktonic community structure were investigated. The average alkenone-derived SST for the last glacial period was ~3°C lower than that measured for the Holocene. Prior to the deglaciation, the lowest SSTs coincide with the highest measured fluxes of organic biomarkers, which represent primarily a planktonic suite of diatoms, coccolithophorids, dinoflagellates, and zooplankton. We propose that intensification of winter northeast monsoon winds during the last glacial period resulted in deep convective mixing, cooling SSTs and enhanced primary productivity. In contrast, postglacial (~17 ka) SSTs are warmer during times in which biomarker fluxes are high. Associated with this transition is a planktonic community structure change, in which the ratio of the average cumulative flux of diatom biomarkers to the cumulative flux of coccolithophorid biomarkers is twice as high during the deglacial and Holocene than the average ratio during the last glacial period. We suggest that this temporal transition represents a shift from a winter northeast monsoon-dominated (pre-17 ka) to a summer southwest monsoon-dominated (post-17 ka) wind system.


1. Introduction

[6] Seasonal reversal in the pattern of atmospheric circulation across the northern Indian Ocean and central Asia is a major feature of the Earth’s climate. During summer, the southwest monsoon (SWM) is responsible for most of annual precipitation across a large area from eastern Africa to the Indian subcontinent. As the Tibetan Plateau is heated, a gradient of temperature and pressure is formed over the northern Indian Ocean and central Asia, which initiates an expansive airflow from south of the equator [Clemenc et al., 1991]. This flow is accompanied by the low-level Eddy Jet [Feldluster, 1974] that blows parallel to the coast of the Arabian Peninsula and induces a complex pattern of Ekman transport away from coastal regions in the western Arabian Sea. The filaments and eddies of cold nutrient-rich water that form as a result of Ekman transport stimulate high levels of primary production in the western Arabian Sea, and parts of the northeastern Arabian Sea along the Pakistan margin [e.g., Brock and McClain, 1992; Henzo et al., 1999; Nair et al., 1989]. During the modern-day SWM, sea surface temperatures (SSTs) on the Oman margin reach values as low as 23–24°C within the upwelling region [Dahl and Oppo, 2006] and increase from west to east with distance from the coast. The SWM-induced upwelling is responsible for 67% of total new primary production in the world ocean [ Chavez and Taggweiler, 1995] and hence plays an important role in the global carbon cycle. Indeed, on glacial-interglacial timescales, the extent to which the Arabian Sea behaves as a sink for CO2 may exert control on the efficiency of the global biological pump [Ris et al., 2005], which, in turn, may influence global climate via feedback mechanisms [Hales et al., 2005].

[7] The pattern of summer atmospheric circulation is reversed as temperature and pressure gradients between the Indian Ocean and the Tibetan Plateau change direction during the winter. Consequently, the northeast monsoon (NEM) dominates over most of the northern Indian Ocean during the winter season. The NEM also induces relatively high levels of primary productivity by lowering the SST and thereby increasing the depth of the mixed layer through convective mixing [Haake et al., 1993; Wocham et al., 2002]. As a result of this mixing, nutrients that are otherwise trapped below the thermocline are mixed into the euphotic zone and become available to primary producers.
Pumping induced depletion from two streams

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Abstract

We have proved that the Hantush's model [Hantush MS. Wall near streams with semi-permeable banks. J. Geophys. Res. 1965;70:2630-38] in a half-domain can be extended to a whole-domain and becomes identical to that of Hunt [Hunt B. Unsteady stream depletion from ground water pumping. Ground Water 1999:37(1):98-102] for a shallow and infinitely narrow stream, provided that the Dupuit assumption is adopted. This proof helps correct a false concept that regards the Hantush's model as less useful because of its fully penetrating stream assumption. This study deals with interaction of an aquifer with two parallel streams based on the Hantush's model. Semi-analytical solutions are obtained based on rigorous mass conservation requirement by maintaining continuity of flux and head along the aquifer-streambed boundaries. This study shows that the hydraulic conductivity ratio of the two streambeds appears to be the most important factor controlling the stream-aquifer interaction, followed by a less important role played by the thickness ratio of the two streambeds. When the low-permeability streambeds do not exist, the steady-state stream depletion from one stream is linearly proportional to the ratio of the shortest distance from the pumping well to the other stream over the shortest distance between the two streams. When the low-permeability streambeds are present, similar conclusion can be drawn except that the stream depletion now also strongly depends on the hydraulic conductivity ratio of the two streambeds. When the values of the hydraulic conductivity of the two streambeds are different by an order of magnitude, the location of the pumping well that receives equal flux from two streams can be off the middle line between the two streams by nearly 99%. © 2006 Elsevier Ltd. All rights reserved.

Keywords: Aquifer-stream interaction; Stream depletion; Low-permeability streambed; Mass conservation; Two streams

1. Introduction

Groundwater and stream interaction has been an active research area in hydrology because of the need of watershed management and water rights distribution. There is a consensus among hydrologists that groundwater pumping near a stream will inevitably affect the stream flow, thus water rights related to groundwater and surface water must be considered together. Although sophisticated numerical models might be needed to deal with realistic situations, many input parameters needed in these models might not always be available. Thus, analytical models are still commonly used by hydrologists and water managers to deal with stream-aquifer interaction [16,35,6]. This is [30] probably the first one who analytically studied pumping induced groundwater-stream interaction for a fully penetrating stream perfectly connected with the adjacent aquifer. His work was later generalized by Glover and Balmer [11] and Jenkins [18] which have become standard tools for water management and water rights distribution, despite of serious limitations for many realistic problems [35]. Hantush [14] considered pumping near a fully penetrating stream but considered a low-permeability streambed separating the stream from the aquifer.

In recent years, several investigators have considered pumping induced interaction of groundwater with partially penetrating streams. For instance, Hunt [16] developed a model for studying the interaction between groundwater and a zero-penetrating, narrow stream. Zlotnik et al. [36]...
Strontium isotope variations in the lower Mississippi River and its estuarine mixing zone

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Abstract

The spatial and temporal variations of elemental and isotopic Sr in the Mississippi River (MR) mixing zone are examined in an attempt to address the extent to which estuarine environments modify the fluvial Sr flux on its way to the ocean. We collected samples from the MR delta and its outflow region during four cruises that took place from 1999 to 2002. MR discharge varied from about 5600–30,000 m³ s⁻¹. Mixing patterns revealed minimal non-conservative behavior of Sr in the dissolved pool. Monthly measurements of the Lower MR at an anchored site during 2000 shows that Sr input to the Gulf of Mexico from the MR varies temporally in both elemental concentration and isotopic composition, and that the flux of Sr is largely a function of water discharge. The extent of the non-conservative geochemical behavior of Sr does not compromise the use of Sr isotope ratios for stratigraphic dating purposes.

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Keywords: Strontium; δ¹⁸O_Sr; Spatial; Temporal; Mississippi River; Gulf of Mexico

1. Introduction

At any given time, the world’s ocean is isotopically uniform with respect to Sr. This is because Sr has a long residence time (2.5×10⁶ a) compared to the short mixing time (~10⁴ a) of water in the ocean (Brass, 1976; Burke and Denison, 1982; Carpo and DePaolo, 1990; McArthur, 1991; Henderson et al., 1994). Therefore, biogenic and authigenic marine precipitates that have formed synchronously at different places in the world’s ocean should incorporate Sr of the same isotopic signature. Measurements of the δ¹⁸O_Sr isotope ratio of these precipitates reveal past ocean Sr isotope variability, which can be an important tool for correlating and/or dating marine sequences (Burke and Denison, 1982; McKenzie et al., 1986; McArthur, 1990; Patterson et al., 1994; Veizer et al., 1997; Vaiisi, 2000).

Most of the observed changes in the Sr isotope ratio of the ocean through time are caused by changes in the relative contributions of hydrothermal exchange at ocean ridges versus weathering of rocks on the continents (Palmer and Edmond, 1989; Edmond, 1992). Hence the evolutionary history of the Sr isotope composition of the ocean may yield important information on global tectonic and/or climate change events (Burke and Denison, 1982; Aberg and Wickman, 1987;...
Travel-time distribution from a finite line contamination source to an extraction well with regional flow

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Abstract

Adveective transport from a finite line contamination source to an extraction well with regional flow depends on interplay of radial and regional flows, a scheme commonly encountered in capture zone delineation. We have investigated travel-time distribution from a finite line contamination source and the associated breakthrough curves (BTCs) observed at an extraction well. The resulting travel-time distribution and BTCs depend on dimensionless source length, dimensionless pumping rate, and inclined angle of the source with respect to the regional flow, where the dimensionless terms are lumped parameters involving source length, pumping rate, distance between the source and the extraction well, aquifer thickness, and regional flow discharge. The observed concentration at the extraction well increases with time in a sub-linear manner. When the source orientation is perpendicular to the regional flow, the dimensionless first arrival time only depends on the dimensionless pumping rate whereas the dimensionless steady-state arrival time depends on both the dimensionless pumping rate and the dimensionless source length. The steady-state concentration at the extraction well is sensitive to the dimensionless source length and the inclined angle of the source with respect to the regional flow, but not sensitive to the dimensionless pumping rate. Two special cases where the extraction well is very close to the source and the regional flow can be negligible have also been discussed.

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Keywords: Adveective transport; Breakthrough curve; Travel time; Non-uniform flow

1. Introduction

Solute transport in a non-uniform flow field is a difficult problem to deal with in subsurface hydrology, at least in an analytical perspective [11, 12, 22, 23, 21, 19], where non-uniform flow refers to a flow that does not have a constant velocity vector. The primary difficulty comes from transport along curved streamlines with variable dispersion coefficients. However, such a problem is of importance in many practical applications. For instance, groundwater remediation using an extraction well is often associated with transport in a non-uniform flow field caused by superposition of radial and regional flows. Conventionally used forced gradient tracer tests require interpretation of tracer breakthrough curves in radial or curved flow fields [17, 12]. Transport in non-uniform flow fields has been investigated by many scientists such as Hoopes and Harleman [11, 12] and others [5, 8, 15, 22]. However, it still remains to be a challenging problem. Available solutions on the subject are often limited to simple non-uniform flow fields such as strictly radial flow.

A primary conclusion of Hoopes and Harleman's study [11, 12] is that advection was dominant and local dispersion would only affect very early breakthrough curves (BTCs) for transport between an injecting well and a pumping well. This conclusion was later proved by field experiments [9, 10]. Lu and Zhang [15] used a stochastic approach to study impact of heterogeneity on capture zones. Cunningham et al. [4] pointed out that heterogeneity had only a minor effect on the breakthrough curves caused by travel...
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A method of calculating pumping induced leakage

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KEYWORDS
Leaky aquifer; Leakage rate; Leakage volume; Analytical solutions; Aquifer management

Summary We have discussed pumping induced leakage in a leaky-confined aquifer bounded by a relatively thin aquitard whose storage effect is neglected. Both constant-rate and constant-drawdown, fully penetrating vertical pumping wells are considered. We have derived closed-form analytical solutions of the steady-state leakage rates and volumes within any given radial distance from the well for both the constant-rate and constant-drawdown pumping wells. For the constant-rate well, we have derived the closed-form analytical solutions for the total leakage rate and volume over the entire aquitard—aquifer boundary at a given time; and the semi-analytical solutions for calculating the leakage rate and volume within any radial distance from the pumping well at a given time. For the constant-drawdown well, we have further provided the analytical solutions of the leakage rate and volume in the Laplace domain; those solutions are numerically inverted to yield results in the real time domain. With the scale-invariant relationship of [Butler Jr., J.J., Tsou, M.-S., 2003. Pumping-induced leakage in a bounded aquifer: an example of a scale-invariant phenomenon. Water Resour. Res. 39(12), 1344; doi: 10.1029/ 2002WR001484.], the solutions of the total leakage rates and volumes can be generalized to finite size aquifers with lateral impermeable boundaries. These solutions are useful for managing multi-layer aquifers in which pumping induced water transfer across the aquitards can occur. © 2006 Elsevier B.V. All rights reserved.

Introduction

Many natural aquifers are semi-confined where aquitards separate them from adjacent aquifers. When groundwater is withdrawn from one aquifer, transfer of water from the adjacent aquifer to the pumped aquifer will occur, a process termed leakage. Pumping induced leakage across aquitards could be an important water budget component that must be considered in groundwater management. The early work on the semi-confined aquifer system was probably pioneered by Hantush and Jacob (1955), Hantush (1964, 1967), and further developed by Neuman and Witherspoon (1969a,b), Bear (1972), Zlotnik and Zhan (2005), and many others. Petroleum engineers also have great interests in the subject because of the need to deal with oil migration across less permeable semi-confining layers (Streitsova, 1988). Most studies on this subject concern vertical pumping

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Detection of near-surface horizontal anisotropy in a weathered metamorphic schist at Llano Uplift (Texas) by transient electromagnetic induction

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Abstract

The use of transient controlled-source electromagnetic prospecting to detect buried, steeply dipping foliation in metamorphic rocks is illustrated with data acquired over the Precambrian Pucksaddle schist in the Llano Uplift of central Texas. The azimuthal variation of the transient voltage at a given transmitter-receiver separation about a fixed central point is consistent with the forward model response of a homogeneous halfspace exhibiting horizontal electrical anisotropy. The loop-loop exploration configuration is ideally suited to probe horizontal anisotropy. A quantitative match of the forward response to the observed data produces measurable electrical conductivity values and coefficient of anisotropy for resistive, crystalline geological materials. The most conductive direction consistently lies within a few degrees of the geologically mapped foliation strike direction. The electrical anisotropy is strongest below the near-surface weathered layer, within the more competent bedrock. The agent responsible for generating the anisotropy cannot be definitively determined, because it is likely to be a combination of geological factors, such as weathering, compositional banding and microcracking, all of which enhance electrical conductivity parallel to the plane of foliation. The transient electromagnetics is supplemented by DC resistivity and seismic surveys. The elastic anisotropy is evident in the near-surface weathered layer, but it may not persist very deep into the underlying competent schist. The exposure of foliated schist at the surface is not sufficient to rule out a possible role for systematically aligned macrofracture sets as a secondary cause of the observed anisotropy.

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Keywords: Electrical anisotropy; Time domain electromagnetics; Schist; Foliation; Geophysical prospecting

1. Introduction

The time-domain electromagnetic (TDEM) geophysical prospecting technique has rarely been used to map horizontal transverse anisotropy in crystalline rocks, primarily because quantitative interpretation of the data is difficult. This study combines new numerical modeling with azimuthal TDEM data acquisition from a Precambrian metamorphic schist in central Texas to detect subsurface electrical anisotropy and to explore the geological mechanisms that might generate it. DC resistivity and seismic surveys also were conducted to provide a supplementary assessment of the anisotropy.

Most previous studies of electrical anisotropy for near-surface (i.e. depths < 100 m) applications have used azimuthal DC resistivity methods (Bhattacharya and Patra, 1968; Watson and Barker, 1999; Busby, 2000). Two parameters are required to describe electrical
Steady flow to a horizontal drain in an unconfined aquifer with variable thickness

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KEYWORDS
Analytical element method; Water table; Horizontal drain; Variable thickness aquifer; Genetic algorithm

Summary In this study, we have used an analytical element method together with genetic algorithm (GA) optimization to determine the steady-state flow rate to an infinite horizontal drain with a finite radius in an unconfined aquifer with a variable thickness. In this study, we first determine the water table position by using the GA optimization method, which is carried out by satisfying the zero pressure and the perpendicularity of iso-potential and iso-pressure gradients on the water table. Then, we illustrate that one has to use a weighting factor in implementing the above-mentioned two conditions simultaneously to optimize the objective function better. Here, we propose two methods to calculate the flow rate to the drainage. The first method determines the flow rate based on the water table elevation using the Dupuit–Forchheimer assumption. The second method determines the flow rate by differentiating the hydraulic head. The flow rates calculated by these two methods agree with each other, especially in the regions that are more than 1.8 dimensionless distance from the drain, where the dimensionless distance is defined as the ratio of distance over the drain elevation. The functionality of the flow rate with respect to the drain radius, the drain elevation, and the distance to the constant head boundary is also studied.

Introduction

Determination of the steady-state flow rates to horizontal drains is an important topic in agriculture and ground water studies. Such drains are used to collect the recharge water or contaminants from an aquifer, enhance sand accretion on beaches (Liet al., 1994), drain water from irrigation fields, lower groundwater levels in urban regions, and also exploit ground water. In general, flow to the drain approaches a steady state quite rapidly. Calculation of the steady-state flow rate to the drain is not simple because of non-negligible vertical flow component near the drain, existence of free water table surface, and variation of saturated aquifer thickness.
Sonar Imaging of Bay Bottom Sediments and Anthropogenic Impacts in Galveston Bay, Texas

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Abstract

Knowledge of surface sediment distribution in Galveston Bay is important because it allows us to better understand sedimentary processes and how human activities impact the bay and its ecosystems. In this project, six areas of bay bottom were surveyed using acoustic techniques to make maps of bay bottom types and to investigate the types and extent of anthropogenic impacts. A total of 12 mi\textsuperscript{2} (-31 km\textsuperscript{2}) was surveyed in six areas, one in Bolivar Roads (2.4 mi\textsuperscript{2}, 6.1 km\textsuperscript{2}), one near Redfish Island (1.2 mi\textsuperscript{2}, 3.1 km\textsuperscript{2}), two in East Bay (4.5 mi\textsuperscript{2}, 12 km\textsuperscript{2}), one southeast of the Clear Lake entrance (2 mi\textsuperscript{2}, 5.2 km\textsuperscript{2}), and one in Trinity Bay (1.7 mi\textsuperscript{2}, 4.4 km\textsuperscript{2}). We used side-scan sonar (100 kHz and 600 kHz) to image the bay bottom and chirp sonar (2-12 kHz) to image sub-surface sediment layers and bottom topography. In the side-scan records, objects as small as a few meters in extent were visible whereas the chirp sonar records show sub-bottom sediment layers with a vertical resolution of about 4 in. (10 cm). The side-scan images display strong contrasts in the amount of sonar return from the bay bottom, highlighting differences in bottom texture and sediment type. The Bolivar Roads and Redfish Island survey areas displayed varied acoustic returns ranging from weak to strong, indicating differences in bay bottom sediments from fine to coarse. The southern East Bay survey site shows a uniform backscatter while the northern East Bay site, Clear Lake Entrance site, and Trinity Bay survey site showed generally low backscatter surrounding sub-circular, high backscatter likely indicative of oyster beds. Chirp sonar records were classified as nine seismic reflection types based on differences in seismic returns and stratigraphy. Parallel, layered sediments are seen filling the bay valley and resting atop the surface formed by erosion prior to filling of the bay. Along the flanks of the alluvial valley, the acoustic response returned an absent or weakly laminated signal, whereas areas of high oyster productivity are characterized by mounds, strong surface returns, and strong, shallow, sub-surface reflectors surrounding current oyster reefs. Anthropogenic features imaged with the sonar include sediment disturbances, such as the ship channels, dredge holes, gorges, and trawl marks, as well as debris, such as submerged boats, pipes, and unidentified objects. Surface sediment and core samples collected in the survey areas correlated well with the side-scan and chirp records. In areas of high amplitude returns, stiff sediments or coarse shell debris were collected, whereas areas of low amplitude returns contained soft mud. The majority of the cores contained mud with small shell fragments near the bay floor.

Introduction

Few studies have been conducted concerning anthropogenic impacts on the bay bottom and large scale sedimentation patterns in Galveston Bay. These types of data are important for geologists, engineers, and biologists because knowledge of surface sediment distributions and anthropogenic perturbations on the bay bottom will have a large effect on sedimentation, potential hazards, and biological production within the bay. Since Galveston Bay is partly surrounded by major cities and industrial areas it is widely used and modified in order to keep channels and passages clear for commercial use.
Enhancement of wind erosion by fire-induced water repellency

Sujith Ravi, Paolo D'Odorico, Bruce Herbert, Ted Zobeck, and Thomas M. Ovet

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The occurrence of fire and the subsequent increase in wind erosion are known to affect vegetation dynamics in dryland landscapes. Fires act as a disturbance on shrubs and trees and expose the soil surface to the erosive action of wind, thereby affecting the loss and redistribution of soil nutrients. Despite the relevance of wind erosion and fires to the dynamics of arid ecosystems, the interactions between these two processes remain poorly understood. We have investigated how a representative water repellent organic compound released by burning biomass and absorbed in the soil may enhance soil erodibility. To this end, we carried out a series of wind tunnel experiments, laboratory tests, and theoretical analyses to assess the effect of fire-induced water repellency on the soil susceptibility to wind erosion. The experiments were carried out using clean, well-sorted sand which was artificially coated with palmitic acid, a common water repellency inducing fatty acid found in many plants. The results indicate that fire-induced water repellency enhances soil erodibility, causing a drop in wind erosion threshold velocity. The results are explained by the effect of water repellent compounds on soil-water contact angle and on the strength of interparticle wet-bonding forces.


I. Introduction

The occurrence of fire and the subsequent increase in wind erosion are known to affect the composition and structure of vegetation in dryland landscapes. Fires contribute to determine the dominance or codominance of woody plants (trees and shrubs) and grasses in arid and semiarid ecosystems [e.g., Scholes and Archer, 1997; Higgins et al., 2000; Van Langevelde et al., 2003; Surkan et al., 2004].

Vegetation in turn, affects the fire regime, in that both fire intensity and frequency depend on the relative abundance of trees and grasses [e.g., Anderegg et al., 2002; Van Wilgen et al., 2003]. Fire suppression and overgrazing have been conjectured to be able to trigger a sequence of processes, known as “bush encroachment,” leading to the conversion of desert grasslands into shrublands [e.g., Archer et al., 1988; Archer, 1989; Van Auken, 2004]. Bush encroachment is often associated with the formation of vegetation patterns characterized by patches of woody vegetation separated by bare ground. The emergence of this two-phase landscape [e.g., Schlesinger et al., 1999] may result from the positive feedback inherent to the removal of nutrient-rich soil from the intercanopy areas, to its deposition onto vegetated patches, and to the consequent formation of “islands of fertility” [Schlesinger et al., 1990]. Wind erosion is often invoked as a major factor causing soil removal from intercanopy areas and deposition in shrub patches [Okin and Gillette, 2001]. Thus, by exposing the soil surface to the erosive action of winds [Zobeck et al., 1989; Okin and Gillette, 2001], disturbances, such as fires, grazing, and climate fluctuations, act as initiators of grassland-to-shrubland conversions, while wind erosion maintains and enhances these local heterogeneities in nutrient and vegetation distribution [Schlesinger et al., 1990; Schlesinger and Gramenopoulos, 1996].

Despite the relevance of wind erosion and fires to the dynamics of arid and semiarid ecosystems, the interactions between these two processes remain poorly understood. Recent experimental evidence [Whicker et al., 2002] suggests that fires enhance soil susceptibility to wind erosion: the erodibility of burned and adjacent bare unburned soil plots was found to be significantly different in the desert shrublands of the American Southwest. The burned sites were observed to exhibit lower threshold velocities for wind erosion and higher volumes of soil loss. This finding remains partly unexplained, in that it is unclear why adjacent sites, with similar surface roughness and exposure to winds, should have differing susceptibility to wind erosion. Here we show that, by affecting the strength of interparticle wet-bonding forces, fire-induced water repellency enhances soil erodibility, causing a drop in wind erosion threshold velocity (the minimum velocity for erosion to occur). Thus the mechanisms causing the enhancement of postfire soil erodibility are associated with postfire soil hydrophobicity.

Fire are known for having a major impact on infiltration, runoff and water erosion [e.g., DeBano, 2000]. The postfire increase in runoff and soil erosion is caused by the decrease in infiltration capacity resulting from fire-induced water repellency [Cromes and DeBano, 1965; DeBano, 1966]. Organic compounds of chaparral and other
Supporting Student Conceptual Model Development of Complex Earth Systems Through the Use of Multiple Representations and Inquiry

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ABSTRACT

Students organize scientific knowledge and reason about issues in the Earth sciences by manipulating internally-constructed mental models and socially-constructed, expressed, conceptual models. The Earth sciences, which focus on the study of complex, dynamic, Earth systems, may present unique cognitive difficulties to students in their development of authentic, accurate expressed conceptual models of these systems. This pilot study came about as we were seeking to construct inquiry modules to assist undergraduate students as they developed an understanding of eutrophication along the coastal margin, a good example of a complex, dynamic, environmental process. We developed coupled use of physical models and information technology (IT)-based multiple representations with an inquiry-based learning environment that allowed our students to develop and test their conceptual models based on available evidence and to solve authentic, complex, and ill-constrained problems. Our hypothesis was that the quality of students' conceptual models would predict their performance on inquiry modules, and that students' prior knowledge (measured by number of previous courses in geology) would mediate the strength of the relationship between students' model expression and their inquiry performance. Statistical results of this study indicated such a relationship existed only among students in the high prior knowledge group. In the light of our findings, we make recommendations for pedagogical accommodations to improve all undergraduates' abilities to understand complex, dynamic, environmental systems, with a particular emphasis on students who have lower levels of prior knowledge.

INTRODUCTION

Student Conceptual Model Development - Cognitive scientists and science education researchers have used the term mental model to describe internal representations of external, natural phenomena (Gentner and Stevens, 1983; Johnson-Laird, 1983; Johnson-Laird and Byrne, 1991; diSessa, 1993; Doyle and Ford, 1998). A mental model becomes expressed once it is represented or communicated through drawings, symbols, objects or words. Recently in Earth science education, the term conceptual model has been used to describe student expressed mental models, defined as an accurate, reasonable representation of natural phenomena that is adopted by groups and indicates a level of expertise (Cazee and Moreira, 2000; Libark et al., 2003). Scientific models, a type of conceptual model, are studied by scientists as cognitive tools to aid in experimental design, develop understanding of complex systems through comparisons with observations, and to make qualitative and quantitative predictions concerning system behaviors under specified conditions. Engagement in authentic practices, which are similar to the activities and tasks performed by scientists, is recommended as a way to support conceptual change among students (Carey, 1965; Vosniadou and Brewer, 1987; She, 2004).

Understanding and manipulating conceptual models of complex Earth systems can present significant learning difficulties for many students (Herbert, 2005). Common learning issues include limited meaningful conceptual understanding of associated knowledge domains and the use of naïve models that guide explanations (Sanger and Greenbowe, 1997; Harrison and Treagust, 1998; Coll and Treagust, 2003; Guisasola et al., 2004). Specific learning issues surrounding student understanding of complex Earth systems include student conceptualization of dynamic Earth systems in static dissected terms and identification of a single causal factor to explain complex natural phenomena (Rata, 2005).

The Role of Prior Knowledge in the Development of Conceptual Models - It is well established that prior knowledge influences learning (Metzner and Wandesree, 1998; She, 2004). A common view of learning is that students construct new knowledge and understandings based on what they already know (Bransford et al., 1999); this view is often considered a constructivist view. It is based on the premise that the learner selects and transforms information from past and current knowledge into new constructs and decisions. Since students come to courses in the Earth sciences with a range of prior knowledge, skills, beliefs, and misconceptions, their abilities to remember, reason, solve problems, and acquire new information is affected (Bransford et al., 1999). If the instructor pays attention to the prior knowledge of their students, it has been evidenced that learning is enhanced (Bransford et al., 1999). Although there may be a number of other variables that may affect student learning of complex Earth systems, e.g. student science attitudes, motivations, instructor pedagogical content knowledge, gender differences, and student visualization/spatial
Mutual Induction and the Effect of Host Conductivity on the EM Induction Response of Buried Plate Targets Using 3-D Finite-Element Analysis

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Abstract—A finite-element analysis of electromagnetic induction (EMI) in the presence of multiple buried metal targets is undertaken for the purpose of unexploded ordnance (UXO) detection and discrimination. The effects of mutual coupling between metal targets and the host conductivity are shown to be important. At high frequencies, mutual coupling is strong, and effects of host conductivity are relatively minor. At lower frequencies near the resistive limit, EMI responses are very small, but the effect of host conductivity becomes important. This is due to the galvanic current flow in the host medium that dissipates charge accumulations on the host/target interfaces. Qualitative analysis of induced current patterns in metal targets demonstrates that mutual coupling is strongly affected by target orientation and skin depth. Rigorous forward modeling of EMI responses is essential to understanding UXO sensor signatures so that discrimination between live UXO items and harmless fragments and clutter may become possible.

Index Terms—Eddy currents, electromagnetic induction (EMI), finite-element methods (FEMs), geophysics, mutual coupling.

I. INTRODUCTION

The contamination of land by unexploded ordnance (UXO) continues to be a major environmental problem [1]. Electromagnetic induction (EMI) sensors have long been used for UXO detection and characterization [1]–[4], but their full potential has not yet been realized in part because of the lack of rigorous three-dimensional (3-D) forward modeling tools. A major limitation of current EMI technology is the ability to discern multiple UXO targets and to distinguish intact UXO from clutter or UXO fragments. The problem is exacerbated by the fact that the metal objects are embedded in a conductive, heterogeneous soil that contributes a certain amount of signal-generated geological noise [5] to the EMI response.

In order to increase the accuracy of subsurface interpretations and to design new EMI sensor arrays for improved UXO classification ability, it is important to understand theoretically the EMI response of buried metal targets. In particular, the case of multiple buried metal targets is important due to the interaction between the targets and between the target and the host.

In this study we investigate frequency-domain EMI responses of two closely spaced, buried metal plates. In particular, we analyze the magnitudes of the plate–plate interaction and host–plate interaction over a wide frequency range of 30 Hz–30 kHz. We show that both interactions are very important constituents of the total EMI response and cannot be neglected in a complete analysis of EMI data for UXO characterization.

The present study should be viewed as a starting point for further detailed, rigorous analysis of frequency and time-domain EMI responses of multiple UXO targets buried in conductive soils alongside clutter and fragments.

A few comments concerning rigorous modeling of 3-D EMI responses are warranted. First, we point out that it is incorrect to conceptualize low-frequency EM induction as a wave scattering problem. The governing physics is that of diffusion rather than wave propagation. In the Maxwell equations, energy dissipation terms associated with diffusion are orders of magnitude larger than energy storage terms associated with wave propagation (e.g., [6]).

Similarly, modeling the EMI response of multiple buried targets, or a single target of complex geometry composed of different materials, as independent oscillating magnetic dipoles ignores the important fact that the targets and their constituent parts are distributed in space and flux-linked to each other. Also, modeling the electromagnetic response of a buried target as if it were located in free space neglects potentially important leakage currents between the target and the surrounding earth.

Finally, we argue that the transmitter should be modeled as a finite-sized loop rather than a magnetic dipole since often the UXO targets are located in the “near-field” of the transmitter—in fact, frequently beneath the interior of the transmitter (TX) loop. In such cases, approximating the TX loop by a magnetic dipole is inappropriate. Recent field measurements of the EMI effects of near-surface buried conductive targets [7] reveals the shortcomings of these common approximations to the full 3-D EMI problem in geological media.

II. FINITE-ELEMENT ANALYSIS

In this paper, the 'A. 'l': finite-element (FE) method [8]–[10] is used to solve the governing Maxwell diffusion equations. Our FE analysis algorithm has the capability for local mesh refinement, which readily permits discretization of the subsurface into an unstructured grid, allowing element edges to coincide with the boundaries of irregular subsurface inhomogeneities, and fine mesh discretizations in the vicinity of large electrical conductivity contrasts. Finite-element analysis is similar in execution speed, storage requirements, and solution accuracy to the finite-difference method.
Flow to a horizontal well in an aquitard–aquifer system

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Abstract

A horizontal well is sometime installed in an aquifer beneath a water reservoir to get significant amount of groundwater with better quality. As aquitards often separate the surface water body from the underneath aquifer, previous studies in vertical wells related to this subject treated leakage from the aquitard as a volumetric source term in the governing equation of flow in the main aquifer, a hypothesis termed “Hantush’s approximation for partially penetrating wells”. In this study, flow in the aquitard and aquifer is treated as two systems which are linked through the continuity of flux and head at the aquitard–aquifer boundary. In particular, we treat leakage as a boundary at the aquitard–aquifer interface, not as a volumetric source. The leakage induced by the pumping horizontal well depends on several parameters such as the aquitard thickness, the vertical hydraulic conductivity of the aquitard, the aquitard specific storage, the well location, and the well length. In general, we find that the solution based on the Hantush’s approximation to some extent deviates from that obtained based on the actual scenario of leakage through the interface during the transient flow condition, particularly at the early time. For steady-state flow, the Hantush’s approximation works reasonably well under realistic conditions of aquitard thickness and hydraulic conductivity as long as the aquitard thickness is relatively thick (aquitard–aquifer ratio greater than 0.01). This approximation also works reasonably well under realistic horizontal well length and well location as long as the well is not too close to the aquitard–aquifer boundary.
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Keywords: Hantush’s approximation; Leaky aquifer; Horizontal wells; Groundwater–surface water interaction; Water supply

1. Introduction

Groundwater is commonly withdrawn near a surface water body such as a river, a stream, a lake, or a water reservoir because the quality is expected to be better than that of surface water. An aquitard often separates the surface water body from the underneath aquifer. Hydraulic connection between surface water and groundwater has long been recognized as a crucial factor in the management of water resources, ecologic conservation, irrigation and drainage, and many other subjects. Therefore, there are extensive studies about pumping induced stream–aquifer interaction (Theis, 1941; Glover and Balmer, 1954; Hantush, 1965; Barkow and Moench, 1998; Hunt, 1999, 2003; Butler et al., 2001; Kolot and Zlotnik, 2003). At present, most of these studies are focused on vertical wells.
Origin of the Pacific Jurassic quiet zone

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ABSTRACT
Understanding the marine magnetic anomaly record is critical for constructing realistic geodynamo models of global geomagnetic field, polarity reversal mechanisms, and long-term geomagnetic field behavior. One of the least understood portions of the marine magnetic anomaly record is also the oldest part of the record, the Jurassic quiet zone (JQZ), where anomalies become weak and difficult to correlate. The reason for the existence of the JQZ is unclear. It has been suggested that the JQZ is a true polarity superchron, similar to the Cretaceous normal superchron. Continental magnetotrastrigraphic studies have suggested that the JQZ is a period of rapid polarity reversals, of low field intensity, or both. We show results of a deep-tow survey of Pacific Jurassic crust that confirms the existence of magnetic anomalies within the JQZ. We tie Ocean Drilling Program Hole 801C (166.4 Ma) into the record and show that seafloor-spreading magnetic anomalies are present around the hole and extend to 170 Ma crust. We find a rise in reversal rate with increasing age with reversal rates over 80 rev/m.y. at 160 Ma and at 167 Ma. Anomaly amplitudes decrease in the record from 155 Ma until 162 Ma, where low-amplitude anomalies are difficult to correlate. Prior to 167 Ma, anomalies remain uniform and are strong throughout the end of our record at 170 Ma. The JQZ thus appears to be a combination of low-amplitude magnetic anomalies combined with rapid field fluctuations, which could be due to either intensity or polarity changes.

Keywords: Jurassic, magnetotrastrigraphy, marine magnetic anomalies, geomagnetism, polarity reversals.

INTRODUCTION
The Jurassic magnetic record lacks a continuous land magnetotrastrigraphic section (Opdyke and Channell, 1996), which makes it imperative that we glean as much information as possible from the remaining contemporaneous marine record. Jurassic ocean crust is the oldest remaining crust in the ocean basins, which restricts the marine magnetic record to a few rare occurrences (Cadée et al., 1978; Larson and Chase, 1972; Larson and Hilde, 1975; Vogt and Eitzch, 1979). Jurassic quiet zone (JQZ) crust is found either at great ocean depths, which attenuate anomaly amplitudes, or is directly adjacent to continents and buried under thick marginal sediments (Bassett and Keen, 1976). The best Jurassic marine magnetic record is arguably in the western Pacific, although it has the disadvantage of being in tropical latitudes where diurnal variations are large compared to sea-surface anomaly amplitudes. We can overcome the attenuation and signal-to-noise issues with a deep-towed magnetic survey of the relevant magnetic anomaly sequences. This study focuses on Jurassic crust located in the Pigafetta Basin of the western Pacific, between 16°S and 21°N and 155°E and 163°E (Fig. 1). At this site, anomalies are optimally expressed due to rapid spreading rates and minimal sediment cover. Pacific Jurassic crust is bounded by three sets of magnetic lineations: Phoenix lineations to the south, Japanese lineations to the northwest, and Hawaiian lineations to the east. These lineations delineate the spreading history of the Pacific plate and also define the boundaries of the Pacific JQZ (Fig. 1). The young boundary of the JQZ was originally defined as chron M22 (Lamon and Chase, 1972). This was pushed back successively to M25 (Larson and Hilde, 1975), to M29 (Cadée et al., 1978), and to M38 (163 Ma) (Hanschmacher et al., 1988), showing that no clear boundary to the JQZ exists. A 1992 deep-tow study (Sager et al., 1998) identified anomalies from M27 back to M40 (Fig. 2) within a young boundary of the JQZ. The identification of magnetic anomalies in the Pigafetta Basin that are devoid of the ubiquitous Cretaceous seamounts that cover the region. The results of this study questioned the idea that the JQZ is a period of no reversals, i.e., a magnetic quiet zone (Sager et al., 1998). The corollary also includes Ocean Drilling Program Hole 801C, which penetrates Jurassic basement without any overlying Cretaceous volcanics (Abrams et al., 1993; Lancelot and Larson, 1990; Pank et al., 2000). The Hole 801C magnetic results show a mean inclination of ~40°, implying that the crust formed at a paleoleatitude of 23°S (Tivey et al., 2005). Furthermore, the downhole results also show more than one polarity reversal within the 474 m drilled basaltic crust, indicating rapid reversals (Tivey et al., 2005) during this period, consistent with contemporaneous terrestrial seamounts (Delcastel et al., 1997; Steinzer et al., 1997).

NEW DEEP-TOW MAGNETIC DATA
We collected 1550 km of deep-towed profiles between 21° and 17°N extending from M35 in the north to the rough-smooth (R-S) basement and magnetic boundary in the south, thought to be the oldest limit of JQZ crust (Abrams et al., 1993; Hanschmacher et al.,...)
20. PALEOMAGNETISM OF THE IGNEOUS SECTION, HOLE 1213B, SHATSKY RISE\textsuperscript{1}

M. Tominaga\textsuperscript{2}, W.W. Sager\textsuperscript{2}, and J.E.T. Channell\textsuperscript{3}

ABSTRACT

Paleomagnetic measurements were made on 52 samples from the igneous section of Ocean Drilling Program Hole 1213B for the purpose of determining paleoinclination and polarity and giving insight about volcanic emplacement. Samples were taken at approximately even intervals from the three basaltic sills that make up the section, and all samples were demagnetized using an alternating field or thermal methods in an effort to determine the characteristic magnetization direction. Half of the samples gave inconsistent results. Furthermore, natural remanent magnetization values were strong and median destructive field values were low, implying that the basalts are prone to acquiring an overprint from the drill string. In addition, hysteresis results show low coercivities and lie in the pseudosingle-domain field of a Day plot ($M_{r}/M_{s}$ vs. $B_{c}/B_{r}$). All of these observations suggest that the samples are characterized by a low-coercivity magnetic mineral such as titanomagnetite, that may not always preserve a stable characteristic remanence. Nevertheless, 26 samples produced consistent inclinations, giving shallow negative values that are considered the likely characteristic direction. There is no statistical difference between mean inclinations for the three units, implying they erupted within a short time. Measurements from all reliable samples were averaged to give a paleoinclination of $-9.3^\circ$ with 95% confidence limits from $-41.8^\circ$ to $27.5^\circ$, the large uncertainty resulting from the fact that paleocooling variation is not averaged. Although the large uncertainty makes a unique assignment of polarity difficult, the interpretation that is most consistent with other Pacific paleomagnetic data is that the magnetization has a reversed polarity acquired slightly north of the equator.


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Non-Darcian flow in a single confined vertical fracture toward a well

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Summary. Non-Darcian flow towards a well which fully penetrates a confined single vertical fracture is presented in this paper on the basis of the Izbash equation. We have obtained semi-analytical solutions for non-Darcian flow by using the Boltzman transform and developed the non-Darcian flow well functions for cases with and without the effect of wellbore storage. The results show that the non-Darcian flow type curves are more or less deviated from the Darcian flow type curve. The non-linear effect is mainly attributed to the turbulent factor, \( v \), a dimensionless parameter related to the pumping rate, the fracture aperture, the fracture thickness, and two constants \( k' \) and \( n \) used in the Izbash power-law. The non-linear effect appears to be less sensitive to the power-law index, \( n \). When excluding wellbore storage, the well function at early times is proportional to \( v^{-(p-1)/2} \), where \( u \) is a dimensionless term inversely proportional to time; whereas the well function at late times is approximated as \( v^{-(p-1)/2} \). When considering wellbore storage, drawdowns inside the well with different \( v \) values approach the same asymptotic value at small times, and the effect of wellbore storage is only found at the early stage of pumping.

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Introduction

Fractured aquifers or rocks contain important water resources in many parts of the world. Groundwater flow to a production well in fractured rocks could have high velocities near the well and deviates substantially from that described by Darcy's law, which gives a linear relationship between...
Drilling to Gabbro in Intact Ocean Crust


Sampling an intact sequence of oceanic crust through lavas, dikes, and gabbros is necessary to advance the understanding of the formation and evolution of crust formed at mid-ocean ridges, but it has been an elusive goal of scientific ocean drilling for decades. Recent drilling in the eastern Pacific Ocean in Hole 1256D reached gabbro within seismic layer 2, 1.157 meters into crust formed at a superfast spreading rate. The gabbros are the crystallized melt lenses that formed beneath a mid-ocean ridge. The depth at which gabbro was reached confirms predictions extrapolated from seismic experiments at modern mid-ocean ridges. Melt lenses occur at shallow depths at faster spreading rates. The gabbros intrude metamorphosed sheeted dikes and have compositions similar to the overlying lavas, precluding formation of the cumulate lower oceanic crust from melt lenses so far penetrated by Hole 1256D.

Ocean crust formed at mid-ocean ridges covers more than 60% of Earth's surface, yet our understanding of its accretion at mid-ocean ridges and evolution on the ridge flanks has been severely limited by the extreme difficulty of direct sampling. Remote geophysical measurements have produced imaging models for the structure of oceanic crust, including the size and shape of magma chambers at mid-ocean ridges (1-3), but the lack of direct sampling in situ crust has prevented testing these models. Gabbros are coarse-grained mafic rocks commonly formed from slow cooling of magma chambers beneath mid-ocean ridges. Drilling a complete section of upper oceanic crust down to gabbro will enable testing models for the formation and structure of oceanic crust (4-9).

Multichannel reflection seismic (MCS) profiling of active intermediate and fast-spreading ridges commonly shows bright reflectors at depths of 1 to 4 km that have the properties expected for a dunite (20-100 m) lens of partial melt (10-14). These melt lenses extend less than 1 km from the ridge axis and crystallize to form gabbroic rocks. The depth to the reflectors decreases as spreading rate increases (Fig. 1) (13, 16); it is controlled by the rate of magma supply from below and hydrothermal cooling by seawater from above (7). Melt lenses are hypothesized to play a critical role in the formation of the lower oceanic crust. According to the "gabbro glacier" model (6-8), as oceanic crust spreads away from the ridge axis, the accumulated crystal residues in these melt lenses subside to form the lower ocean crust, which is the major portion of the crust. Alternative models, however, argue that the lower crust is formed by injection of slabs at various depths (3, 17) and that the geophysics suggested melt lens is simply the most shallow intrusion. In addition to geophysical studies, our understanding of oceanic basement and particularly the plutonic portion of the crust comes from observations of ancient oceanic rocks exposed on land inShielded, onshore exposures of active ridges and deep-sea tectonic exposures, and drilling. The origin of opaline diabase in marginal basins and the dissection of tectonically exposed lower crust, however, make the relevance of these observations to intact ocean crust questionable. Precious deep drilling in intact crust has only once penetrated the transition from lavas to dikes, in Ocean Drilling Program (ODP) Hole 504B, which reached a total depth of 1036 m sub-hydrostatic (18). Unfortunately, Hole 504B failed to penetrate the dike-gabbro boundary because of hostile drilling conditions in fractured dikes at high temperatures. Although fault-exposed lower ocean crust has been drilled in several places (19-23), the geological context of such cores is often unknown. The critical transition from dike to gabbro has previously never been cored. Deep drilling into basement at Site 1256 recently, Integrated Ocean Drilling Program (IODP) Expeditions 309 and 312 deepened Hole 1256D in the eastern Pacific to 150 m below seafloor (1256D; 1257 m; multichannel reflectivity - sediment thickness), drilling through lavas, the underlying sheeted dike complex, and into gabbroic rocks. This is the first penetration of the dike-gabbro boundary in intact ocean crust since the inception of deep sea drilling nearly 40 years ago. Hole 1256D thus provides unique samples of the lithologic transitions in the upper crust, from lavas to dikes and from dikes to gabbros. The dike-gabbro boundary is key to understanding crustal structure and the interplay between magmatic accretion and hydrothermal cooling.

The recognition of an interval of superfast spreading rates, up to 220 mm/year full rate (24) on the Cocos-Pacific plate boundary between 19 and 12 million years ago (24) led to the choice of ODP Site 1256 (Fig. 2) as the optimal site for deep drilling (25). Scientific ocean drilling mainly targets relatively soft, easily cored sediments. In contrast, coring into the underlying, much harder, basaltic basement is less common and most holes are shallow (<800 m) (25). Deep (>500 m) basement drilling requires a substantial commitment of resources but yields major scientific rewards by sampling otherwise inaccessible regions of Earth's interior. A deep drill hole at the fastest possible spreading rate tests the prediction that a melt lens reflector is more shallow at higher spreading rates, and also minimizes the drilling needed to sample an intact section from lavas to gabbros, because the upper crust is thinner. This is an important advantage considering the cost time, and technical challenges of deep drilling. Assuming that ~300 m of lavas flowed off-axis, the depth to gabbros was predicted to be between 1023 to 1300 mbsf (1275 to 1550 mbsf) at Site 1256 (26).

Drilling at Site 1256 was initiated in 2002 on ODP Leg 206 when Hole 1256D was drilled through 250 m of sediment and 502 m into basement (25). Coring continued to 1255 mbsf in 2003 by IODP Expedition 309, and recently Expedition 312 deepened the hole to 1507.1 mbsf and into gabbros (27). Almost 5 months at Site 1256 were required to achieve the operational and scientific objectives.

Results from drilling. Gabbros were first intersected at 1157 mbsf (1407 mbsf), within the predicted target zone (26). The uppermost crust at Site 1256 is composed of ~100-m-thick sequence of lava dominated by a single flow up to 75 m thick, requiring at least this much seawater relief to pool the lava. On modern fast-spreading ridges, such topography does not normally develop until 5 to 10 km from the axis (28). The lavas immediately below include

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Experimental studies of oxygen isotope fractionation in the carbonic acid system at 15°, 25°, and 40°C

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Abstract—In light of recent studies that show oxygen isotope fractionation in carbonate minerals to be a function of HCO₃⁻ and CO₃²⁻ concentrations, the oxygen isotope fractionation and exchange between water and components of the carbonic acid system (HCO₃⁻, CO₃²⁻, and CO₂) were investigated at 15°, 25°, and 40°C. To investigate oxygen isotope exchange between HCO₃⁻, CO₃²⁻, and H₂O, NaHCO₃ solutions were prepared and the pH was adjusted over a range of 2 to 12 by the addition of small amounts of HCl or NaOH. After thermal, chemical, and isotopic equilibrium was attained, BaCl₂ was added to the NaHCO₃ solutions. This resulted in immediate BaCO₃ precipitation; thus, recording the isotopic composition of the dissolved inorganic carbon (DIC). Data from experiments at 15°, 25°, and 40°C (1 atm) show that the oxygen isotope fractionation between HCO₃⁻ and H₂O as a function of temperature is governed by the equation:

$$1000 \text{ln} \frac{\delta^{18}O_{HCO_3^-}}{\delta^{18}O_{H_2O}} = 2.59 \pm 0.00 \left(10^7 \text{T}^{-2}\right) + 1.89 \pm 0.04$$

where δ is the fractionation factor and T is in Kelvin. The temperature dependence of oxygen isotope fractionation between CO₃²⁻ and H₂O is

$$1000 \text{ln} \frac{\delta^{18}O_{CO_3^{2-}}}{\delta^{18}O_{H_2O}} = 2.39 \pm 0.04 \left(10^7 \text{T}^{-2}\right) - 2.70 \pm 0.46$$

The oxygen isotope fractionation between CO₂ and H₂O was investigated by acid stripping CO₂ from low pH solutions; these data yield the following equation:

$$1000 \text{ln} \frac{\delta^{18}O_{CO_2}}{\delta^{18}O_{H_2O}} = 2.52 \pm 0.03 \left(10^7 \text{T}^{-2}\right) + 11.12 \pm 0.33$$

These results show that pH can have a significant effect on the δ¹⁸O of the DIC, which can vary by as much as 17% at a given temperature. Copyright © 2005 Elsevier Ltd

I. INTRODUCTION

Analyses of stable oxygen isotopes have been central in understanding the evolution of the Earth's past climate, oceans, and atmosphere. For instance, Urey (1947), McCrea (1950), Epstein et al. (1953), and many others have shown that temperature and the oxygen isotope composition of the water in which carbonate minerals precipitate control the oxygen isotope composition of the mineral. The temperature-dependent fractionation of ¹⁸O into carbonate minerals has been used by many investigators to study ancient climate change (e.g., Frenkl, 1955; Popp et al., 1986; Veizer et al., 1986). However, little work has been done to assess if there are other factors that control oxygen isotope fractionation. A recent experimental study of slowly precipitated synthetic carbonate minerals revealed that the oxygen isotope composition (δ¹⁸O) of calcite (CaCO₃), wetherite (BaCO₃), and aragonite (CaCO₃) can also be a function of the initial HCO₃⁻ and metal ion concentrations of the solution (Fig. 1A) (Kim and O'Neil, 1997). Sproo et al. (1979) showed that the isotopic composition of foraminiferal calcite can vary as a function of CO₂ concentration at a constant temperature (Fig. 1B). These is clearly a need to understand not only the isotopic behavior of mineral-water systems, but also the fractionation between dissolved inorganic carbon species (CO₂, HCO₃⁻, and CO₃²⁻) and water.

Chemical interactions among dissolved inorganic carbon species (carbonic acid) are described by the following relationships (Morne and Mackenzie, 1990):

$$\text{CO}_2(g) \leftrightarrow \text{CO}_2(aq) \quad (1)$$
$$\text{CO}_2(aq) + \text{H}_2\text{O} \leftrightarrow \text{H}_3\text{CO}_3 \quad (2)$$
$$\text{H}_2\text{CO}_3 \leftrightarrow \text{HCO}_3^- + \text{H}^+ \quad (3)$$
$$\text{HCO}_3^- \leftrightarrow \text{CO}_3^{2-} + \text{H}^+ \quad (4)$$

The relative distribution of these species depends on pH (Fig. 2). At low pH, CO₂ is predominant whereas at high pH CO₃²⁻ dominates. Each of these species is known to have a different equilibrium oxygen isotope fractionation with respect to water (McCrea, 1955; Udoowski et al., 1991) and, thus, pH influences the isotopic distribution in the carbonic acid system. There have been many studies to understand the carbon isotope fractionation in the carbonic acid system (e.g., Vogel et al., 1970; Moos et al., 1974; Zhang et al., 1995) as well as oxygen isotope fractionation in the sulfate–water and phe...
Analytical study of capture zone of a horizontal well in a confined aquifer

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Abstract

We have presented analytical solutions for the capture zones of infinitely long horizontal wells in a homogeneous, confined aquifer with uniform flow. We find that the capture width enlarges and the bisector line of the capture zone moves toward the centerline of the aquifer when moving away from the well in the upstream direction for an arbitrary well location. The capture width and bisector line approach their ultimate width and position, respectively, after a distance of about 1.5 times the aquifer thickness. The ultimate capture width depends on the well discharge but not on the well location. We have plotted the ultimate bisector line position versus discharge for different well locations. Compared to the capture zone of a fully penetrating vertical well in an isotropic and laterally infinite aquifer, the ultimate capture width of a horizontal well is smaller than that of a vertical well given the same discharge rate per unit length. Furthermore, the relationship between the ultimate capture width and the well discharge rate is non-linear, in contrast to the linear behavior often observed in the vertical well capture zone.

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Keywords: Horizontal well; Capture zone; Analytical solution; Confined aquifer; Potential theory

1. Introduction

Wells that are placed horizontally in a porous medium have been applied to the remediation of contaminated ground water (Langseth, 1990; Tarbighz, 1992; Cleveland, 1994; Wilson and Kenda, 1994; Sawyer and Lienallen-Dulan, 1998). A horizontal well with a large screen length can influence a large planar area during remediation, and is more efficient in removing contaminant relative to vertical wells (Sawyer and Lienallen-Dulan, 1998). In the case of an aquifer with uniform flow, a horizontal well oriented perpendicularly to the direction of uniform flow can prevent spreading of contaminant plume effectively. Steward (1999) has used a mathematical model to compare the capture zones of horizontal wells perpendicular and parallel to the direction of uniform flow with those of a fully penetrating, a partially penetrating, and a series of partially penetrating vertical wells. A capture zone for a well is defined as a part of an aquifer whose ground water will flow to that well. Steward (1999) concluded that
5. Measured Permeabilities of Diatomaceous Sediments and Pelagic Clay from the Northwest Pacific, ODP Site 1179

Ohmyoung Kwon, Karen Mobley, and Richard L. Carlson

ABSTRACT

One of the objectives of drilling at Site 1179 was to search for microbes or biochemical evidence of microbial activity as part of the ongoing exploration of the depth and extent of the deep biosphere. The existence of living microbes has not been confirmed, but the chemistry of pore waters from the site, such as sulfate and ammonium profiles, is consistent with sulfate reduction and nitrification by anaerobic bacteria. However, chemical profiles are affected by the movement of molecules and ions through porous sediments by diffusion and advection. Permeability is thus an important consideration in the interpretation of pore water chemistry profiles. Moreover, diatomaceous sediments have some unique and, as yet, poorly understood physical properties. The purpose of this research is to measure hydraulic conductivity (permeability) in a suite of sediment samples from Ocean Drilling Program Site 1179 by the transient-pulse method. The sample set consists of four diatom oozes samples from Unit I, one radiolarian ooze sample from Unit II, and one pelagic clay sample from Unit III. The permeability of the clay is 1.92 μd, whereas the permeabilities of the overlying radiolarian and diatom oozes range from 289 to 1604 μd. Among these samples, permeability increases with porosity and grain size, in keeping with the results of previous studies.
Effects of buoyancy and mechanical layering on collisional deformation of continental lithosphere: Results from physical modeling

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Abstract

We use two suites of lithospheric-scale physical experiments to investigate the manner in which deformation of the continental lithosphere is affected by both (1) variations of lithospheric density (quantified by the net buoyant mass per area in the lithospheric mantle layer), $M_g$, and (2) the degree of coupling between the crust and lithospheric mantle (characterized by a modified Amperian ratio, $\phi_{CM}$). Models with a positively buoyant lithospheric mantle layer ($M_g > 0$ and $\phi_{CM} > 0$) result in distributed root formation and a wide deformation belt. In contrast, models with a negatively buoyant lithospheric mantle layer strongly coupled to the crust ($M_g < 0$, $\phi_{CM} > 0$, and $\phi_{CM} = -0.2$, and $\phi_{CM} = 10^{-6}$) exhibit localized roots and narrow deformation belts. Synfrontal delamination of the model lithospheric mantle layer and a wide deformation belt is exhibited in models with negatively buoyant lithospheric mantle layers weakly coupled to the crust ($M_g < 0$, $\phi_{CM} < 0$, and $\phi_{CM} = 10^{-6}$). Synfrontal delamination of the continental lithosphere may initiate due to buoyancy contrasts within the continental plate, instead of resulting from wedging by the opposing plate. Rayleigh–Taylor instabilities dominate the style of deformation in models with a negatively buoyant lithospheric mantle layer strongly coupled to the crust and a slow convergence rate ($M_g < 0$ and $\phi_{CM} > -0.2$). The degree of coupling ($\phi_{CM}$) between the model crust and lithospheric mantle plays a lesser role in both the style of lower-lithospheric deformation and the width of the crustal deformed zone with increasing density of the lithospheric mantle layer.

Keywords: Delamination; Lithospheric buoyancy; Wedging; Collision; Experiments

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Evaluation of Platinum Electrodes and Three Electrode Potential Standards to Determine Electrode Quality

P. R. Owens,* L. P. Wiking, L. M. Lee, and B. E. Herbert

ABSTRACT

The pre-installation evaluation of Pt electrodes in electrode potential (Eh) standards is crucial for reliable field interpretations. During a routine check of electrode quality in three different Eh standards before field installation, inconsistent and variable results were recorded. Due to the preliminary observational results, the purpose of this study was to (i) elucidate why Eh readings in the same buffer were different before and after soaking in water, (ii) identify the most rigorous standard for detecting poor electrode function, and (iii) determine causation for disparity in the electrode performance in Eh standards when using constructed Eh electrodes. Electrodes were evaluated in quinhydrone in pH 4 buffer and pH 7 buffer and ferrous-ferric sulfate solutions. Additionally, an experiment was developed to intentionally expose Cu in Eh electrodes with decreasing areas of the metal exposed. Finally, aqueous macroscopic electrochemical and Fourier Transform Infrared spectroscopic evaluations of Cu in the three standards were conducted to characterize and quantify the reduction-oxidation reactions of Cu. This study found that quinhydrone in pH 7 buffer was not a rigorous standard for determining improper function of Pt electrodes constructed utilizing Cu wire. Due to the interrelationship between the reduction-oxidation potential of Cu and Eh standards with low pH proved to be a more rigorous standard.

The measurement of Eh is a standard procedure for wet soils investigations. Reduction-oxidation potentials are indicators of nutrient availability, mobility of heavy metals, and are also important in the development of pedogenic properties such as soil color, iron depletions, and concentrations (Sigg, 2000). The reduction-oxidation potential is a measure of the propensity of redox-specific chemical reactions to occur. Since soils are heterogeneous and most commonly are not at thermodynamic equilibrium, an Eh measurement is composed of mixed potentials and has no quantitative utility. Given the problems with interpretation of Eh and double determination in the field, this parameter is still used. The Eh measurements are quick, simple to obtain, and infer useful information regarding biogeochemical reactions that are possible in soils and sediments. Also, given the numerous theoretical problems with Eh measurement in mixed potential environments, it is extremely important to ensure the electrodes are functioning properly before installing in the soil. Quinhydrone in pH 7 buffer, quinhydrone in pH 4 buffer (Patrick et al., 1996), and ferrous-ferric sulfate (Light, 1972) are three common laboratory standards that are used to check the proper functioning of Eh electrodes before use.

BACKGROUND OF THE PROBLEM

Twenty 50-cm Pt Eh electrodes were procured from a non-commercial source. The electrodes were constructed by cutting 1.0-mm diam. (18 gauge) Pt wire into 1.3-cm segments (Fig. 1). The Pt segments were soaked in a 1:1 mixture of concentrated nitric and hydrochloric acids for about 4 h to remove contamination of other metals from the surface. The segments were soaked in distilled water overnight. Three millimeters of the Pt wire segments were inserted in the end of a drilled 2.6-mm diam. (10 gauge) solid Cu wire. The Cu wire was crimped to make electrical connection and to secure the Pt wire segment. Exposed Cu was covered with a clear waterproof epoxy, purchased at a local hardware store (brand name was not provided), so the Pt was the only metal exposed to the redox reaction. In the last step, heat shrink tubing was used to cover the epoxy. This type of Eh electrodes construction is modified from the design described by Faulkner et al. (1989) and Musilir et al. (1985) and typically inserted directly into the soil. Before shipment these electrodes were validated in quinhydrone buffered at pH 7. The data were shipped with the electrodes.

Upon receiving the electrodes they were soaked in water overnight and rechecked with quinhydrone in pH 4 buffer and quinhydrone in pH 7 buffer solutions. After checking, only 4 of the 20 electrodes were within the acceptable range listed in Methods of Soil Analysis (Patrick et al., 1996) for quinhydrone in pH 4 after soaking in water overnight. However, 19 of the 20 electrodes were within the range with quinhydrone in pH 7 buffer after soaking in water overnight. Due to the conflicting data of the electrodes checked in quinhydrone in pH 4 and pH 7 standards, several experiments were conducted with the following objectives.

OBJECTIVES

1. Elucidate why Eh readings in the same buffer were different before and after soaking in water?
2. Identify the most rigorous standard for detecting poor electrode function.
3. Determine causation for disparity in the electrode performance in Eh standards when using constructed Eh electrodes.

MATERIALS AND METHODS

Preliminary Experiment on the Procured Electrodes

After the initial checks, ten of the procured 50-cm electrodes were randomly selected from the batch of 20. Five electrodes were left unaltered and five were re-processed. On

<table>
<thead>
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<th>Abbreviations</th>
<th>Eh, electrode potential; FTIR, Fourier Transform Infrared Reflectance; SEM, scanning electron microscope.</th>
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1541
Radionuclide and biomarker proxies of past ocean circulation and productivity in the Arabian Sea

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We present new excess 231Pa/230Th activity ratios and lipid biomarker results from northeastern Arabian Sea sediments (core 93KL) spanning the past 50 ka in an effort to constrain further the relationship between climate at low and high latitudes. 231Pa/230Th activity ratios are maintained at values significantly higher than the water-column production ratio of 0.093. Average 231Pa/230Th activity ratios are lower during the last glacial period than during the Holocene. The lower 231Pa/230Th activity ratios coincide with the timing of Heinrich Events 1–5. Profiles of lipid biomarker fluxes and 231Pa/230Th activity ratios from 32 to 12 ka show similar patterns, suggesting that 231Pa is more efficiently scavenged relative to 230Th at times when diatoms make up a proportionally larger part of the primary biomass signal. In the Holocene, high 231Pa/230Th activity ratios may indicate enhanced 231Pa export from the southern to the northern Indian Ocean via intensified thermohaline circulation. Citation: Pourmand, A., F. Marcantonio, T. S. Bianchi, E. A. Camel, and E. J. Waterston (2005), Radionuclide and biomarker proxies of past ocean circulation and productivity in the Arabian Sea, Geophys. Res. Lett., 32, L10610, doi:10.1029/2005GL022612.

1. Introduction

High-frequency Dansgaard-Oeschger (D-O) cycles first recognized in the Greenland ice cores [Dansgaard et al., 1993; Grootes et al., 1993] represent intense (stadal) and intermediate (interstadial) cold intervals during the last glacial period that vary with 1000-, 1450-, and 3000-year frequencies. These cycles are associated with low-frequency Heinrich events of massive iceberg discharge into the North Atlantic Ocean [Bond et al., 1995; Heinrich, 1988] and are not limited to changes in the climate of the North Atlantic, but have been found to be global in extent [e.g., Altabet et al., 2002; Behl and Kennett, 1996; Peterson et al., 2000; Schulz et al., 1998; Stott et al., 2002]. In the Arabian Sea, high-resolution studies of variations in primary productivity proxies (e.g., organic carbon content [Schulz et al., 1998] and δ15N [Altabet et al., 2002]) have shown an atmospheric linkage between North Atlantic and low-latitude climate change. Periods of a strengthened southwest monsoon, during which upwelling is intensified, are consistent with the timing of D-O interstadials [Altabet et al., 2002; Pourmand et al., 2004]. Here, we employ a multi-proxy approach to constrain the causes of, and responses to, abrupt climatic change in the northeastern Arabian Sea (core 93KL; 23°35′N, 64°13′E; water depth of 1,802 m) over the past 50 ka.

2. Methods

Sediment was sampled between depths of 5 and 477.5 cm spanning the past 50 ka in core 93KL (see Figure 1 of Pourmand et al. [2004] for location). All samples were spiked with 239Pa (half-life of 26.9 days) and digested with concentrated HNO3, HF, HCl, and HClO4 in accordance with the procedure described by Lao et al. [1992]. 231Pa was isolated and purified using ion exchange chromatography and analyzed by isotope dilution analysis on an Element 2 Inductively Coupled Mass Spectrometer (ICP-MS) at Tulane University. Replicate analyses indicate an average external reproducibility of less than 3% for 231Pa.

In order to calculate 231Pa/230Th ratios, corrections need to be applied for a) the ingrowth of 231Pa and 230Th from autigenic U and b) the supported activities of 231Pa and 230Th in the detrital fraction. 230Th activities for the samples analyzed here for 231Pa are reported by Pourmand et al. [2004]. It has been shown that in the majority of the world’s oceans the flux of 230Th to the sediments is equal to its production rate in the overlying water column [e.g.,
Suspended sediment sources and tributary effects in the lower reaches of a coastal plain stream as indicated by radionuclides, Loco Bayou, Texas

K. M. Yeager · P. H. Santchi · J. D. Phillips · B. E. Herbet

Abstract Characterizing the dynamics of fluvial sediment sources over space and time is often critical in identifying human impacts on fluvial systems. Upland interflow and subsurface sources of suspended sediment at Loco Bayou, Texas, were distinguished using $^{226}$Ra/$^{228}$Th, $^{226}$Ra/$^{228}$Th and, $^{210}$Pb/$^{210}$Pb data. Source contributions were apportioned at three stations during within-bank and flood flows. $^{210}$Pb and $^{210}$Pb (excess $^{210}$Pb) were used to determine floodplain sedimentation; suspended sediment $^{210}$Pb/$^{210}$Pb data mirrored results of Ra/Th, showing dominance of subsurface sources during within-bank flows, changing to interflow sources during flood. This trend corresponds spatially to influx of sediment from ephemeral tributaries, reflecting mobilization of stored interfluvial sediments during flood stage. Upper basin sedimentation was similar but markedly less at the lowerrmost station. These results indicate (1) modified ephemeral tributaries store sediment derived from sheet wash, discharging them during flood, and (2) southernmost Loco Bayou is episodically re-worked, resulting in significantly reduced local rates of sedimentation.

Keywords Radionuclides · Fingerprinting · Suspended sediment · Human agency · Texas · USA

Introduction

Determination of the sources and an improved understanding of the dynamics of suspended sediments in river systems is a challenging but essential endeavor, due to its manifest importance in many fields of environmental science, including water quality (Langedal 1997; Swank and others 2001), the fate and transport of pollutants (Batson and others 1996; Macklin and others 1997; House and others 1997; Marcus and others 2001) and ecological health and diversity (Ryan 1991; Rice and others 2001), as examples. Many specific water quality issues in the U.S., such as section 305 (Clean Water Act), non-point source pollution assessments, and the successful quantification of total maximum daily loads (TMDL) for sediment and absorbed pollutants may hinge directly on determining the sources of sediment delivered to streams. While hydrodynamics and flow regimes are critical controls on sediment transport processes at all scales, the supply of available material, derived from either upland erosion within the drainage basin or channel margins can be of equal or greater importance (Van Sickle and Bescha 1983; Asselman 1999; Bronsdon and Naden 2000). The focus of this work is to apply radiochemical methods to ascertain maximum rates of near channel, floodplain sedimentation and to investigate the relative importance of delineated interfluvial and subsurface sources of suspended sediment within an east Texas fluvial system. The greater Loco Bayou system is typical of many impacted watersheds on the Texas coastal plain, where land use and water supply impacts can result in significant perturbations of fluvial sediment transport dynamics.

Previous research

Delineation or “fingerprinting” of fluvial suspended sediment sources has been accomplished using a variety
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Cation–π Bonding: A New Perspective on the Sorption of Polycyclic Aromatic Hydrocarbons to Mineral Surfaces

Dongqiang Zhu,* Bruce E. Herbert, Mark A. Schultzman, Elizabeth R. Carraway, and Jin Hur

ABSTRACT

Recent molecular modeling and spectroscopic studies have suggested that relatively strong interactions can occur between aromatic π donors and metal cations in aqueous solutions. The objective of this study was to characterize potential cation–π interactions between π donors and exchangeable cations accumulated at mineral surfaces using both spectroscopic and batch sorption methods. Quadrupolar splitting in deuterium nuclear magnetic resonance (1H NMR) spectroscopy for 4,6-dichloro-3-benzene, 4-benzene, and 4-alkylbenzene (DBPA, azobenzene) in aqueous suspensions of a Na-saturated reference montmorillonite unambiguously indicated the ordering of solute molecules with respect to the clay surface. The half-life broadening (ΔHS) of 1H NMR of 4-alkylbenzene in montmorillonite suspensions showed that soft exchangeable cations generally resulted in more benzene sorption compared with harder cations (e.g., Ag > Cr > Na > Mg2+, Ba2+). In batch sorption experiments, saturating minerals (e.g., porous silica gels, kaolinite, vermiculite, montmorillonite) with a soft transition metal or other base cations generally increased the polycyclic aromatic hydrocarbon (PAH) sorption relative to harder cations (e.g., Ag > Cr > K > Na; Ba2+ > Mg2+). Sorption of phenanthrene to Ag+-saturated montmorillonite was much stronger compared with 1,4,5,8-tetrachlorobenzene, a coplanar non- donor having slightly higher hydrophobicity. In addition, a strong positive correlation was found between the cation-dependent sorption and surface charge density of the minerals (e.g., vermiculite, montmorillonite > silica gels, kaolinite). These results, coupled with the observations in 1H NMR experiments with montmorillonite, strongly suggest that cation–π bonding forms between PAHs and exchangeable cations at mineral surfaces and affects PAH sorption to hydrated mineral surfaces.

Polycyclic aromatic hydrocarbons (PAHs) are a group of ubiquitous, nonionic organic chemicals (NOCs) that are of great environmental concern due to their toxicity and suspected carcinogenicity (Fernández et al., 2000; van Meir et al., 2000). Sorption of PAHs to soils and sediments, which is generally controlled by the nature and content of organic matter present in the geosorbents, is a key process controlling the fate and transport of PAHs in the environment (Karichhoff et al., 1979; Means et al., 1986; Lathby et al., 1997). However, as the organic matter content of geosorbents decreases, the relative importance of other geosorbents, including mineral surfaces and nanoparticles, increases. Several environments can have organic matter contents low enough that such mineral surfaces are the dominant sorbents, including low organic carbon soils, some ground water aquifers, atmospheric water droplets (e.g., clouds, fogs, and raindrops), and engineered environmental systems (e.g., clay barriers). Potential mechanisms controlling NOC sorption to hydrated mineral surfaces have been advanced based primarily on batch sorption experiments because of the difficulty in direct spectroscopic observations. Huang et al. (1996) proposed that differences in sorption behaviors of phenanthrene exhibited by external or internal porous surfaces of nonswelling minerals (e.g., α-Al2O3, quartz, kaolinite) and the internal interlayer surfaces of a swelling bentonite clay were caused by their different relative accessibilities to the sorbate, which was mainly affected by near-surface or pore geometry and by the preferential sorption of water. In recent studies by Hundal et al. (2001), the lack of a correlation between Freundlich sorption constants and indices of charge or hydrophobicity of the clay led them to suggest that sorption of phenanthrene by smectites was primarily a physical process via capillary condensation in interlayer nano- or micropores.

Theoretically, several models have been outlined to describe the driving forces for sorption of NOCs by mineral surfaces. Nonionic organic chemical sorption to hydrated mineral surfaces has been ascribed to the "hydrophobic effect," where sorption is driven by a substantial thermodynamic gradient due to a combination of relatively small van der Waals forces and large entropy differences (Tanford, 1980; Israelachvili, 1985; Goss and Eisenreich, 1995). Chiu et al. (1985) have suggested that the sorption of NOCs, such as PAHs, to minerals is a competitive adsorption process by which water molecules and NOCs compete for positions at the mineral surface. It has also been suggested that the nature of adsorbed water at the mineral–water interface, the so-called vicinal water (Drost-Hansen, 1989; Schultzman and Morgan, 1994; Schwarzenbach et al., 2003), serves as a more favorable environment for NOCs to partition from the bulk aqueous phase. None of the models above, however, have been verified by spectroscopic and/or microscopic characterization.

The interaction between small, deuterated molecules and natural organic matter (e.g., humic substance, soil organic matter) or mineral surfaces can be reflected by changes in the deuterium nuclear magnetic resonance (1H NMR) relaxation times (Nanny and Mazza, 2001; Zhu et al., 2003a, 2003b) or quadrupolar splitting (Grandjean and Laurio, 1989; Delville et al., 1991; Weis and Gerasimowicz, 1995) of the 2H nuclei. Deuterium

Abbreviations: 1H NMR, deuterium nuclear magnetic resonance; NOC, nonionic organic chemical; PAH, polycyclic aromatic hydrocarbon; Δ, quadrupolar splitting; ΔHS, half line broadening.
Geochemical and hydrodynamic controls on arsenic and trace metal cycling in a seasonally stratified US sub-tropical reservoir

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Abstract

The phase distribution of trace metals and oxyanions, including U and As, in 2 surface water bodies was investigated within a South Texas watershed hosting a high density of surface U mine pits and tailings. The objectives of the study were to evaluate the environmental legacy of U mining, with particular emphasis on the spatial and temporal variability of water quality in Lake Corpus Christi, a downstream reservoir that serves as the major water resource to a population of ~30,000 people in the region. Lyssy Pond, a livestock pond bordered by U mine tailings, was used as a model case-study site to evaluate the cycling of U mine-derived oxyanions under changing redox conditions. Although the pond showed seasonal thermal and chemical stratification, geochemical cycling of metals was limited to Co and Pb, which was correlated with redox cycling of Mn mineral phases, and U, which suggested reductive precipitation in the pond's hypolimnion. Uranium levels, however, were too low to support strong inputs from the tailings into the water column of the pond. The strong relationships observed between particular Cr, Cs, V, and Fe suggest that these metals are associated with a stable particulate phase (probably allochthonous aluminosilicates) enriched in unreactive Fe. This observation is supported by a parallel relationship in sediments collected across a broad range of sediment depositional processes (and histories) in the basin. Arsenic, though selectively enriched in the pond's water column, was dominated by dissolved species throughout the depth of the profile and showed no sign of geochemical cycling or interaction with Fe-rich particles. Arsenic (and other oxyanions) in the water columns of Lake Corpus Christi and Lyssy pond were not affected by the abundant presence of Fe-rich particles but instead behaved conservatively. No evidence was found of anthropogenic impacts of U mines beyond the purely local scale. Arsenic's presence within the Nueces drainage basin is related to interactions between surface and groundwater with U- and As-rich geological formations rather than large-scale transport of contaminants downstream of the U mine pits and tailings. A quantitative mass balance model, constructed using monthly hydrological data for the reservoir, provides quantitative evidence of seasonal evaporative concentration of As in surface waters demonstrating the predominance of hydrodynamic over geochemical constraints, on the cycling of this element.

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Mechanisms of compaction of quartz sand at diageneric conditions

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Abstract

The relative contribution of cracking, grain rearrangement, and pressure solution during experimental compaction of quartz sand at diageneric conditions was determined through electron and optical microscopy and image analysis. Aggregates of St. Peter sand (255 ± 60 μm diameter grain size and porosity of approximately 34%) were subjected to creep compaction at effective pressures of 15, 34.5, 70, and 105 MPa, temperatures of 22 and 150°C, nominally dry or water-saturated (pore fluid pressure of 12.5 MPa) conditions, and for times up to one year. All aggregates displayed transient, decelerating creep, and volume strain rates as low as 3x10^-19 s^-1 were achieved. The intensity of fracturing and degree of fragmentation increase with volume strain and have the same dependence on volume strain at all conditions tested, indicating that impingement fracturing and grain rearrangement were the main mechanisms of compaction throughout the creep phase. The increase in fracture density and decrease in acoustic emission rate at long times under wet conditions reflect an increase in the contribution of subcritical cracking. No quantitative evidence of significant pressure solution was found, even for long-term creep at 150°C and water-saturated conditions.

Comparison of our findings to previous work suggests that pressure solution could become significant at temperatures or times somewhat greater than investigated here.

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Keywords: compaction; subcritical crack growth; pressure solution; diageneric; microstructures; sandstones; deformation; sedimentary basin

1. Introduction

Observations of quartz-rich sandstone reservoirs document great variability in porosity at similar burial depths, and indicate that several distinct mechanical and chemical processes contribute to consolidation processes over geologic time scales [1–5]. Although porosity loss by advective transfer of solutes from distant sources to sites of cementation may explain porosity variations in some cases, evidence for compaction by
Modelling poroelastic hollow cylinder experiments with realistic boundary conditions

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SUMMARY

A general poroelastic solution for axisymmetrical plane strain problems with time dependent boundary conditions is developed in Laplace domain. Time-domain results are obtained using numerical inversion of the Laplace transform. Previously published solutions can be considered as special cases of the proposed solution. In particular, we could reproduce numerical results for solid and hollow poroelastic cylinders with suddenly applied load/pressure (Rice and Cleary, Rev. Geophys. Space Phys. 1976; 14:227; Schmitt, Tait and Spann, Int. J. Rock Mech. Min. Sci. 1993; 30:1057; Oui and Aboushakran, ASCE J. Eng. Mech. 2001; 127:591). The new solution is used to model laboratory tests on thick-walled hollow cylinders of Berea sandstone subjected to intensive pressure drawdown. In the experiments, pressure at the inner boundary of the hollow cylinder is observed to decline exponentially with a decay constant of 3-5 1/s.

It is found that solutions with idealized step-function type inner boundary conditions overestimate the induced tensile radial stresses considerably. Although basic poroelastic phenomena can be modelled properly at long time following a stepwise change in pressure, realistic time varying boundary conditions predict actual rock behaviour better at early time. Experimentally observed axial stresses can be matched but appear to require different values for ρ and ν than are measured at long time.

The proposed solution can be used to calculate the stress and pore pressure distributions around boreholes under infinite/finite boundary conditions. Prospective applications include investigating the effect of gradually changing pore pressure, modelling open-hole cavity completions, and describing the phenomena of wellbore collapse (bridging) during oil or gas blowouts. Copyright © 2004 John Wiley & Sons, Ltd.

KEY WORDS: poroelasticity, hollow-cylinder test; numerical inversion of the Laplace transform

1. INTRODUCTION

The general theory of a porous material containing a compressible fluid was developed by Terzaghi [1] for one-dimensional consolidation and by Biot [2] for three dimensions.

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1 Sergy Journe died tragically on May 16, 2004. This paper is dedicated to his wife, Svetlana Ouchakova, daughter, Daria Zhurina, mother, Valentina Zhurina, and sister, Elena Zhurina in his memory.
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Water mass stability reconstructions from greenhouse (Eocene) to icehouse (Oligocene) for the northern Gulf Coast continental shelf (USA)

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Shallow water mass characteristics such as temperature and density profile play a critical role in the climate system. We have developed a new method by which to reconstruct the ancient shallow water mass stability on the continental shelf using oxygen isotope variation within mollusc shells and fish otoliths and applied the method to an important interval in Earth history, the most recent transition from Greenhouse (Eocene) to Icehouse (Oligocene) climate modes. We define the slope of summer temperature (density) versus the seasonal range in temperature (density) as an indicator of water mass stability. In addition, extrapolation of the regression to zero seasonality is a proxy for temperature at the bottom of the seasonal thermocline (TBST). During the greenhouse world (the early Eocene and middle Eocene) the water mass plot shows an unstable water mass, agreeing with previous planktonic foraminiferal studies showing that temperature gradients at this time were much smaller than at present. During the middle to late Eocene transition, a substantial increase in water mass stability occurred. Significant cooling (∼5°C) of the TBST at this transition indicates that the greater cooling of deeper water relative to surface water caused the increase in water mass stability. The changes in water column structure at this transition were the most likely cause of a major extinction of planktonic foraminifera from warm to cold water taxa. The late Eocene T-DAT profile is very similar to modern profiles, suggesting that shallow water mass structure became similar to that of the modern Gulf Coastal shelf by the late Eocene. At the Eocene/Oligocene (E/O) boundary, no major change in water mass structure is identified. This agrees with the observation that no major extinction of planktonic foraminifera is found at the E/O boundary. INDEX TERMS: 3364 Meteorology and Atmospheric Dynamics: Paleoclimatology; 1040 Geochemistry: Isotopic composition/chemistry; 4194 Oceanography: General: instruments and techniques. KEYWORDS: Eocene, paleoclimate, greenhouse

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1. Introduction

Surface ocean water mass characteristics such as temperature profile and stability are very important for climate and marine productivity. Various factors such as winds, seasonality (related to latitude and Earth's obliquity), ocean currents, and continental shelf create shallow water characteristics that in turn affect these factors [Andrews and Schmitz, 2000]. Planktonic foraminifera are affected by the depth of mixing related to sunlight penetration and food availability, and the cause of extinction of planktonic foraminifera has been partly attributed to the change in thermocline structure [Nordr, 1992; Boersma et al., 1998]. Furthermore, the depth of the thermocline and the stability of the shallow water mass in the present equatorial Pacific play a critical role in El Niño/Southern Oscillation (ENSO) [Philander, 1990]. In the modern northern Atlantic, the water mass instability induced by higher surface salinity and cold water create North Atlantic Deep Water. In spite of the importance of the shallow water mass stability, it has been difficult to characterize because of a lack of appropriate proxy data. The new method presented here could provide clearer clues to these processes that would otherwise remain hidden in the past.

2] Seasonality has been recognized as an important proxy controlling ice sheet growth as well as biological distributions and chemical weathering [e.g., Valentine, 1983; Axlerod, 1984; Crowley et al., 1986]. One of the best proxies for seasonality is oxygen isotope variation within mollusc shells. By serially sampling across growth lines of mollusc shells and fish otoliths, we can reveal past intra and interannual temperature change [e.g., Sonet et al., 1983; Tuxen et al., 1996; Andrews and Schmitz, 1996, 1998, 2000; Kobashi et al., 2001; Tripathi and Zachos, 2002]. However, because of the substantial change of seasonality with water depth and the difficulty to constrain the water
Water flow from a horizontal tunnel in an unsaturated zone

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Abstract

Flow from a horizontal tunnel in an unsaturated zone is an important factor in calculation of water loss from the conveying tunnel and in predicting the amount of water table built up. This study has investigated the three-dimensional unsaturated flow from a tunnel by using the Extended Richards’ equation. It superposes the point source solution along the tunnel axis to yield the line source solution. For treating the tunnel surface as a saturated-water-current boundary, this study first provides an empirical function to numerically calculate the flux distribution along the tunnel axis. It then provides an analytical solution to calculate flow from the tunnel. We find that the recharge rate from a horizontal tunnel decreases with time and gradually approaches a steady-state rate. The recharge increases with increasing tunnel length and radius, and also with increasing the pore size distribution parameter of the soil. The vertical downward recharge beneath the tunnel becomes constant and equals the total recharge from the tunnel at late time.

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Keywords: Three-dimensional unsaturated flow; Horizontal tunnel; Analytical solution; Richards’ equation

1. Introduction

Utilization of unlined horizontal tunnels for irrigation, conveyance of water from the reservoir to the field, and transit of water from saturated zones to the surface has been introduced in many arid and semi-arid regions (Todd, 1959; Mustafa, 1987; Rai and Singh, 1992, 1995; Ram et al., 1994; Manglik et al., 1997). Seepage from unlined tunnels is a great waste of the precious water resources in arid and semi-arid regions and leads to build up of the water table that creates problems of water logging and salinity. The first step for predicting the amount of water loss and the water table rise is the determination of the percolation rate from the tunnels.

A number of investigators have studied the recharge due to canal seepage and its effect on the water table rise (Schridt and Luthin, 1964; Hattush, 1967; Marino, 1974; Gill, 1984; Mustafa, 1987; Rai and Singh, 1992, 1995; Ram et al., 1994; Manglik et al., 1997). In most of these studies the amount of recharge was assumed constant (Mustafa, 1987; Rai and Singh, 1992, 1995; Ram et al., 1994), and in some cases to decrease with time (Gill, 1984; Manglik et al., 1997). The field experiments also showed that the rate of recharge from the canals decreased with time.
Permeability of illite-bearing shale:  

1. Anisotropy and effects of clay content and loading  

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Permeability of illite-rich shale recovered from the Wilcox formation and saturated with 1 M NaCl solution varies from $3 \times 10^{-22}$ to $3 \times 10^{-19}$ m$^2$, depending on flow direction relative to bedding, clay content (40–65%), and effective pressure $P_e$ (2–12 MPa). Permeability $k$ is anisotropic at low $P_e$, measured $k$ values for flow parallel to bedding at $P_e = 3$ MPa exceed those for flow perpendicular to bedding by a factor of 10, both for low clay content (LC) and high clay content (HC) samples. With increasing $P_e$, $k$ becomes increasingly isotropic, showing little directional dependence at 10–12 MPa. Permeability depends on clay content; $k$ measured for LC samples exceed those of HC samples by a factor of 5. Permeability decreases irreversibly with the application of $P_e$, following a cubic law of the form $k = k_0 \left[1 - (P_e/P_1)^m\right]^m$, where $k_0$ varies over 3 orders of magnitude, depending on orientation and clay content, $m$ is dependent only on orientation (equal to 0.166 for bedding-parallel flow and 0.52 for flow across bedding), and $P_1$ (18–27 MPa) appears to be similar for all orientations and clay contents. Anisotropy and reductions in permeability with $P_e$ are attributed to the presence of crack-like voids parallel to bedding and their closure upon loading, respectively. INDEX TERMS: 5114 Physical Properties of Rocks: Permeability and porosity; 5139 Physical Properties of Rocks: Transport properties; 5112 Physical Properties of Rocks: Microstructure; 1812 Hydrology: Groundwater transport; KEYWORDS: permeability; shale; connected pore space


1. Introduction

Permeabilities of shales and mudstones are much lower than those of sandstones. As a result, subsurface fluid flow may be very rapid within sandstones, whereas flow through shales may be so slow that departures in pore pressure from the hydrostat may be supported over geologically significant time intervals [Dickinson, 1953; Dickey et al., 1968; Chapman, 1972, 1994a, 1994b; Bruce, 1973, 1984; Schmidt, 1973; Bishop, 1979; Plamier, 1986; Harrison and Summa, 1991; Bigelow, 1994]. Laboratory measurements of permeability $k$ for intact shales, mudstones, and clay aggregates vary widely, from $10^{-16}$ m$^2$ to $10^{-20}$ m$^2$ [e.g., Young et al., 1964; Bryant et al., 1975; Lin, 1978; Magara, 1978; Silva et al., 1981; Brenchart et al., 1983; Tavenas et al., 1983; Morrow et al., 1984; Bennett et al., 1989; Katsube et al., 1991; Naziril, 1994; Vassauz et al., 1995; Dewhurst et al., 1996a, 1996b, 1998, 1999; Slomer and Kooches, 1997; Kwon et al., 2001; Harrington et al., 2001]. At the high end of this range, shale units offer little resistance to subsurface flow over long time intervals, but they may serve to divide hydrocarbon reservoirs into fluid compartments over short time intervals. At the low end of the measured range ($k \leq 10^{-12}$ m$^2$), shales may form pressure seals to aqueous fluids, impeding fluid transport over extended, geologic times, even in the absence of capillary effects associated with nonwetting hydrocarbons [e.g., Brenchart and Hanslow, 1968; Bradley, 1975; Hunt, 1990; Denning, 1994].

Much of the observed variation in permeability of shales can be attributed to variations in fabric and clay content. Anisotropy in transport properties may

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Permeability of illite-bearing shale:
2. Influence of fluid chemistry on flow and functionally connected pores

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[1] Bedding-parallel permeability of illite-rich shale of the Wilcox formation has been investigated using distilled water and 1 M solutions of NaCl, KCl, and CaCl₂ as pore fluids. Despite low modal concentrations of swelling clays, specimens expand upon fluid saturation and permeabilities depend on fluid composition. Permeabilities to flow of 1 M CaCl₂ are 3–5 times greater than values measured for the other pore fluids, suggesting sensitivity to exchange of divalent cations for monovalent cations at clay mineral surfaces. Permeabilities of individual samples exhibit nonrecoverable changes with sequential changes in composition of incoming fluid. Permeabilities k at varying effective pressure Pₑ fit a cubic law k = k₀ [1 – (Pₑ/P₁)ⁿ], where m and P₁ are independent of fluid composition, and k₀ is greater for transport of 1 M CaCl₂ than that for transport of the other pore fluids. Assuming that fluid conduits have crack-like dimensions, the lack of sensitivity of m and P₁ to fluid composition suggests that surface roughness and asperity stiffness of conduits are unaffected by cation exchange, while changes in k₀ reflect changes in the clay-fluid interfaces of the connected pore space.

INDEX TERMS: 5114 Physical Properties of Rocks: Permeability and porosity; 5139 Physical Properties of Rocks: Transport properties; 1832 Hydrology: Groundwater transport; 3947 Mineral Physics: Surfaces and interfaces; 1045 Geochemistry: Low-temperature geochemistry; KEYWORDS: permeability, shale, fluid chemistry


1. Introduction

[2] Abnormal pore pressures in sedimentary basins are commonly associated with occurrences of shales[Dickinson, 1953; Dickey et al., 1968; Magara, 1971; Chapman, 1972, 1982, 1994; Schmidt, 1973; Borg and Habel, 1982; Fred and Paeroc, 1989; Bizelow, 1994]. Elevated pore pressures may be generated by a number of processes, including compaction of fluid-saturated sediments [Dickinson, 1953; Magara, 1975a; Hart et al., 1995; Smith and Wilcocko, 1996], transformation of smectites to illite [Powers, 1967; Burst, 1969; Fred and Paeroc, 1989], thermal expansion of fluids [Barker, 1972; Magara, 1975b; Sharp, 1983], and the formation of oil and gas from organic constituents of shales [Hadberg, 1974; Meissner, 1978; Momper, 1978; Illing, 1938; Barker, 1987, 1990; Spencer, 1987, 1994]. Once generated, abnormal pressures may dissipate to equilibrium values along the hydrostatic pressure gradient unless upward fluid flow is limited by overlying units of high capillarity or intrinsically low permeability. Given that abnormal pressures are associated with hydrocarbon generation, shales may form seals to upward migration because of their high capillary pressures to nonwetting fluids [e.g., Berg, 1975; Vavra et al., 1992; Schlomer and Kroos, 1997; Hao et al., 2000]. Shales may also limit the flow of aqueous pore fluids if their permeabilities are sufficiently low [Bredheof and Hanshaw, 1968; Bradley, 1975; Hunt, 1990; Deming, 1994].

[3] Shale permeabilities vary widely (from 10⁻¹⁶ m² to 10⁻²⁸ m²) with values well above and below those required for pressure seals over characteristic geologic and reservoir production times [Young et al., 1964; Magara, 1971; Lin, 1978; Bredhoef et al., 1985; Kataube et al., 1991; Dewhurst et al., 1994, 1999; Kwon et al., 2001]. Permeabilities of shales depend on porosity, clay mineralogy and content and texture [Kataube et al., 1991; Schlomer and Kroos, 1997; Dewhurst et al., 1998, 1999; Revil and Cathles, 1999; Kwon et al., 2004], all of which may change with burial [e.g., How et al., 1976; Lee et al., 1985; Sidd and Jones, 1985; Dovaneski et al., 1986; Kim et al., 1999].

[4] Permeabilities may also depend on pore fluid composition if pore throats available for fluid flow are modified by local clay swelling and formation of hydrated complexes at clay-fluid interfaces [Scott and Smith, 1966; Norrish, 1973; Van Olphen, 1977; Sparks, 1995; Sposito et al., 1999]. Clay aggregates made up of swelling clays exhibit extremely low permeabilities to the flow of water.
Characterizing pyrene–Ag⁺ exciplex formation in aqueous and ethanolic solutions

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Abstract
The primary mechanism responsible for the dynamic fluorescence quenching of polycyclic aromatic compounds (PACs) by Ag⁺ ions is enhanced intersystem crossing from the lowest singlet excited state to the lowest triplet excited state. For some PACs, however, exciplex formation with Ag⁺ in polar organic solvents has also been reported. Quenching of pyrene fluorescence by Ag⁺ in two polar solvent systems (aqueous and ethanolic solutions) was examined here using steady-state and time-resolved fluorescence techniques. In both solvents, quenching led to the formation of a pyrene–Ag⁺ exciplex, (1Py · · · Ag⁺), which rapidly equilibrated with excited singlet pyrene molecules (1Py* and Ag⁺). The exciplex and pyrene monomer emission spectra strongly overlapped, with the dominant exciplex peaks in water and ethanol red shifted from the 0–0 transition of pyrene by 5.08 and 2.56 kJ/mol, respectively. Rate constants for the formation and dissociation of the exciplex were much larger than the radiative and nonradiative decay rate constants for both the excited state monomer and exciplex. The short exciplex fluorescence lifetimes and very low quantum yields observed in the two solvents can be attributed to enhanced nonradiative decay processes for the exciplex. The emission quantum yield of the exciplex formed in aqueous solution was an order of magnitude larger than that in ethanolic solution, which is likely to be attributable to the higher polarity of water versus ethanol.

Keywords: Time-resolved fluorescence; Steady-state fluorescence; Dynamic quenching; Fluorescence lifetime; Rate constants; Quantum yield; Silver ion

1. Introduction

It has been known for some time that mixed or heterocen- cimers (i.e., exciplexes), formed from the interaction between a singlet excited state fluorophore and a quencher, can be intermediates in some fluorescence quenching processes [1,2]. The stability of exciplexes is generally restricted to nonpolar solvents, because in polar solvents the transient complex typically dissociates into radical ions due to the stabilization energy available via solvation [3]. However, even though exciplex formation is observed predominantly in solvents having relatively small dielectric constants, several research groups have recently reported properties of exciplexes formed in polar organic solvents [4–7]. For example,

Dreeskamp and coworkers [8,9] demonstrated the formation of an exciplex between perylene and Ag⁺ ions in polar organic solvents and proposed the reaction model shown in Scheme 1. In this scheme, b1 and b2 are overall rate constants for excited monomer and exciplex relaxation, respectively, and b3 and b4 are rate constants for the formation and dissociation of the exciplex, respectively. Dreeskamp and coworkers also investigated exciplex formation between other polycyclic aromatic compounds (PACs) and Ag⁺ in polar organic solvents based on Scheme 1 [10]. For all PACs studied, Dreeskamp and coworkers showed that b2 is much smaller than b1.

The results of Dreeskamp and coworkers [8–10] suggest that some portion of PACE fluorescence quenching by Ag⁺ ions in polar solvents may be due to exciplex formation. Other research groups [11–13], however, did not observe exciplex emission from pyrene and various metal ions, and instead proposed intersystem crossing (ISC) as the mechanism responsible for fluorescence quenching.
Quantifying ground-state complexation between Ag⁺ and polycyclic aromatic hydrocarbons in dilute aqueous solution via fluorescence quenching

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Abstract

Interactions of Ag⁺ with naphthalene and pyrene in aqueous solution were investigated using ultraviolet (UV) absorption and steady-state and time-resolved fluorescence spectroscopies. Small red-shifts in the two primary absorption bands of naphthalene and pyrene were observed in the presence of high concentrations of Ag⁺, indicating that ground-state cation–aromatic π electron interactions occurred. Ag⁺ complexation constants (κ₁ and κ₂) for naphthalene were determined directly from steady-state and time-resolved fluorescence data, whereas the formation of π pyrene–Ag⁺ exciplex required an additional correction to remove its interference on apparent pyrene complexation constants. The correction utilized ratios of the exciplex and monomer preexponential factors obtained from pyrene fluorescence decay curves measured at several emission wavelengths that were impacted to different degrees by the exciplex emission. The novel approach developed here to quantify ground-state complexes between Ag⁺ and polycyclic aromatic hydrocarbons (PAHs) offers new opportunities to investigate weak metal–organic complexes such as those resulting from cation–π interactions.

Keywords: Pyrene; Naphthalene; Silver ion; Metal complexation; Dynamic quenching; Exciplex; Time-resolved fluorescence; Steady-state fluorescence

1. Introduction

Ever since single ring aromatic compounds were reported to form 1:1 complexes with silver ions [1–3], polycyclic aromatic hydrocarbons (PAHs) have been recognized as potential donor molecules for preparing Ag⁺–aromatic π complexes in aqueous [4–7] and organic solvents [8,9]. The Ag⁺–aromatic π interaction has also been studied in gas [10,11] and solid [12–18] phases. Mulliken [19] formulated a theoretical model for the bonding between silver perchlorate and benzene and Fukui et al. [20] provided a molecular orbital theoretical treatment of the electronic requirements of Ag⁺–aromatic π interactions. Based on these results [19,20], cation–aromatic π interactions are expected to consist of charge-quadrupole, charge-dipole, charge-induced dipole, charge transfer, dispersion force, electrostatic interaction, and hydrophobic components. Recently, Mizakata et al. [21] provided a review on the formation of Ag⁺ ion–PAH complexes in various phases.

Andrews and Keser [4] suggested that the water soluble aromatic π complexes AgAr⁺ and Ag₂Ar²⁺ are in equilibrium with the aromatic compound and free Ag⁺, and that the monomer/complex is predominant in the ground-state. In other words, the complexation constant for Ag₂Ar²⁺ is a minor component in calculating the overall speciation. Kofahl and Lucas [5] determined Ag⁺ complexation constants of various PAHs in an aqueous medium containing KNO₃ and AgNO₃ at ionic strength and in equimolar water–methanol solutions containing NaNO₃ and AgNO₃ at ionic strength 0.5 using a solubility enhancement method. They found that Ag⁺ complexation constants of phenanthrene (Phen) depended significantly on the polarity of the solvent systems. For example, the complexation constant for formation of AgPhen⁺ in aqueous medium was 3.3

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Syncollisional delamination and tectonic wedge development in convergent orogens

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[1] Delamination of the lower crust and lithospheric mantle has occurred in several convergent orogens, most notably the Alps and Pyrenees. Some workers suggest that the process is mechanically similar to tectonic wedging and triangle-zone development, and dependent on the pattern of mechanical layering. A search of over 35 orogens that have been explored by geophysical techniques showed that no correlation exists between crustal composition and delamination. Delamination of passive subducting plate margins is more common than that of tectonically and/or volcanically active overriding margins. Estimates show that the lithospheric mantle of cool passive margins may contain greater net negatively buoyant mass than warmer active margins. The top of the lower lithospheric layer containing the greatest net negatively buoyant mass is aligned with a weak zone near the Moho. Passive margin lithosphere thus has a greater tendency to delaminate during a collisional event than active margin lithosphere. For delamination to initiate above the Moho, the lower crust must be subducted or depressed to allow for exposure to ecolitic geologic conditions. Transformation of the mafic lower crust to mafic eclogite also creates a likely delamination horizon above a lower lithospheric layer containing net negatively buoyant mass aligned with a weak zone in the lithosphere. In contrast to the stratigraphic delamination that is key to the development of small-scale wedge structures, syncollisional delamination is likely to occur in response to an increase in the lateral tectonic stress on a weak horizon already stressed by net negatively buoyant mass in the lower lithosphere. INDEX TERMS 8102 Tectonophysics: Continental contractional orogenic belts; 8122 Tectonophysics: Dynamics, gravity and tectonics; 8150 Tectonophysics: Plate boundary—general (30-40); 8159 Tectonophysics: Rheology—crust and lithosphere; 8164 Tectonophysics: Structures—crust and lithosphere; KEYWORDS: delamination, tectonic wedging, lithospheric buoyancy.

1[1] Although the interpretation of tectonic wedges and syncollisional delamination is becoming more widespread as more orogens are explored by deep geophysical techniques [e.g., Cook et al., 1998; Eaton et al., 1999; White et al., 1999; Keller and Hatcher, 1999], many questions remain. These include the following: (1) Is the subducting continental plate margin always the plate to delaminate? (2) What is the influence of temperature and the associated thermally controlled characteristics of the lithosphere, such as mechanical layering and lithospheric buoyancy, on delamination? (3) What is inherently different about the delaminating plate compared to the wedge forming plate, e.g., irregular plate margin geometry or composition? (4) Is syncollisional delamination and tectonic wedge development at the crustal/lithospheric-scale similar to smaller-scale tectonic wedging and delamination?

2[2] To examine the first question, structural and tectonic characteristics of orogens explored by deep geophysical techniques were compiled and compared. To address the latter questions, we estimate the mechanical layering and buoyancy with depth in converging continental litho-
A comparison of late Paleocene and late Eocene lignite depositional systems using palynology, upper Wilcox and upper Jackson Groups, east-central Texas.

Abstract

The Late Paleocene and early Eocene Wilcox and Jackson groups of east-central Texas are characterized by the development of widespread, marine-dominated, coastal plain depositional systems. Palynological analyses of these groups reveal the distinct climatic signals present in the Gulf coastal plain and the adjacent offshore areas. The Late Paleocene Wilcox Group is characterized by a high diversity of marine and terrestrial taxa, reflecting a warm, humid climate with abundant rainfall. The Early Eocene Jackson Group, on the other hand, is characterized by a lower diversity of marine and terrestrial taxa, reflecting a generally drier climate with reduced rainfall. The palynological record of the Late Paleocene and early Eocene Wilcox and Jackson Groups provide important insights into the climatic evolution of the Gulf Coastal Plain and the adjacent offshore areas during this critical interval of Earth history.
dominates the waveform from a strike–slip earthquake mechanism like the Denali event. Moreover, the propagation of the rupture from north to south should focus seismic wave energy along-strike southward of the rupture owing to the focusing phenomena of directivity. We verify these theoretical predictions by mapping the maximum Denali mainshock amplitudes recorded at broadband seismic stations and new permanent GPS receivers that sample at 1 Hz (ref. 17). Canadian GPS data were provided by the Geodetic Survey Division, Geomatics Canada, and Base Mapping and Geomatics Services, British Columbia Ministry of Sustainable Resource Management. Other contributing geodetic networks include the International GPS Service, the Continuously Operating Reference Stations and the University NAVstar Consortium and Aeromap Services. This new application of GPS technology for measuring seismic waves is essential to defining the pattern of seismic radiation, because the Denali seismic waves saturated all the broadband seismographs within British Columbia and most within the most northerly US.

The combined GPS and seismic data clearly show a focusing of seismic wave energy, or dynamic deformations, consistent with theoretical expectations (Fig. 4). The coincidence of this focusing with theband of triggered seismicity area strongly suggests to us that the dynamic deformations were the triggering agent. However, while this correlation is clearly suggestive, there is not a one-to-one correspondence between the peak amplitude of the dynamic deformation and the change in seismicity rate. This might imply a triggering threshold that depends on tectonic frequency of oscillation. The unprecedented abundance of direct measurements of the dynamic deformation field, albeit at the surface, provides new opportunities to investigate these possibilities.

Figure 4 Map of the distributions of Denali-related seismicity rate changes and measured peak Denali seismic ground velocities. The latter are proportional to dynamic strains at these distances and were recorded at broadband seismic stations (shaded circles) and 1-Hz GPS receivers (open circles). Circles show locations of recording sites with radial projection to the measured peak velocity (blue in inset). All measurements in British Columbia and four in the US are from 1-Hz GPS data; note the good agreement with the nearest seismic measurement. The velocities decrease away from the direction of theoretically expected maximum seismic radiation (green segment of a great circle). We label the seismic cluster at Akih because the measured velocities are too small to be visible. Notably, the size of triggered rate increases for roughly within the same azimuthal span as is defined by the maximum measured velocities and theoretically expected dynamic deformations.

Letters to Nature

Ramp initiation in a thrust wedge

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Collisional mountain belts are characterized by fold and thrust belts that grow through sequential stacking of thrust sheets from the interior (hinterland) to the exterior (foreland) of the mountains belthk. Each of these sheets rides on a fault that cuts up through the stratigraphic section on inclined ramps that join a flat basal fault at depth. Although this step-step ramp–flat geometry is well known, there is a consensus on only a particular ramp form where it does. Perturbations in fault shape, stratigraphy, fluid pressure, folding, and surface slope have all been suggested as possible mechanisms. Here we show that such pre-existing inhomogeneities, though feasible causes, are not required. Our computer simulations show that a broad foreland-dipping plastic strain band forms at the surface near the topographic inflection produced by the previous ramp. This

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Competing financial interests. The authors declare that they have no competing financial interests.

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Variations in productivity and eolian fluxes in the northeastern Arabian Sea during the past 110 ka

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Abstract

High-resolution (one to two samples/ka) radiocesium proxy records from core 9KL in the northeastern Arabian Sea provide evidence for millennial climate variability over the past 110 ka. We interpret 230Th-normalized 230Th fluxes as a proxy for eolian input, and authigenic uranium concentrations as a proxy for past productivity. We attribute orbital and suborbital variations in both proxies to changes in the intensity of the southwest Indian Ocean monsoon. The highest 230Th-normalized 230Th fluxes occur at times that are consistent with the timing of the Younger Deyas, Heinrich events 1–7 and cold Dansgaard-Oeschger stadial events recorded in the GISP2 ice core. Such high dust fluxes may be due to a weakened southwest monsoon in conjunction with strengthened northwesterlies from the Arabian Peninsula and Mesopotamia. Authigenic uranium concentrations, on the other hand, are highest during warm Dansgaard–Oeschger interstadials when the southwest monsoon is intensified relative to the northwesterly winds. Our results also indicate that on orbital timescales maximum average eolian fluxes coincide with the timing of marine isotopic stage (MIS) 2 and 4, while minimum fluxes occur during MIS 1, 3 and 5. Although the forcing mechanism(s) controlling suborbital variabilities in monsoonal intensity is still debated, our findings suggest an atmospheric teleconnection between the low-latitude southwest monsoon and North Atlantic climate.

Keywords: millennial variations; Indian Ocean monsoon; eolian flux; productivity; uranium-thorium

1. Introduction

The southwest Indian Ocean monsoon plays a major role in the Earth’s climate system. A strong pressure gradient forms during northern hemisphere summers between the high- and low-pressure systems over the Indian Ocean and Asian continent, respectively. In turn, this gradient induces major upwelling of nutrient-rich waters in the Arabian Sea. These waters create rates of biological productivity that are among the highest in the world [1,2]. Therefore, changes in productivity are a direct response to climate due to the dependence of upwelling on wind intensity. The mechanism generally called upon to explain variations in monsoon intensification on glacial timescales is precessional forcing, which affects the insolation reaching the Earth [3–7]. Variations in monsoon intensity, and presumably productivity, occur also

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Hybrid fracture and the transition from extension fracture to shear fracture

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Fracture is a fundamental mechanism of material failure. Two basic types of brittle fractures are commonly observed in rock deformation experiments—extension fractures and shear fractures. For nearly half a century it has been hypothesized that extension and shear fractures represent end members of a continuous spectrum of brittle fracture types, and fracture behavior is often described in terms of a stress-dependent transition between these two modes of failure. Observations of transitional fractures that display both opening and shear modes (hybrids) in nature have been rare. Here we present results of triaxial extension experiments on Carrara marble that show a continuous transition from extension fracture to shear fracture with an increase in compressive stress. Hybrid fractures form under mixed tensile and compressive stress states at acute angles to the maximum principal compressive stress direction. Fracture angles are greater than those observed for extension fractures and less than those observed for shear fractures. Fracture surfaces also display a progressive change from an extension to shear fracture morphology.

In the laboratory, a shear fracture is produced under a compressive stress state, shows displacement parallel to the failure surface, and forms at a 40°-45° angle to the maximum principal compressive stress direction, ε (Fig. 1). An extension fracture forms under a tensile stress state, displays an opening-mode displacement to the failure surface, and propagates in an orientation parallel to the maximum and perpendicular to the minimum principal compressive stress. Additional fracture types described in laboratory samples, such as wedging and longitudinal splitting during uniaxial compression, are often assumed to be forms of extension and shear fractures. 

Within the compressive stress regime, the empirical Coulomb–Mohr failure criterion successfully predicts the brittle fracture strength and orientation of shear fractures. This failure criterion is based on the assumption that shear fractures are the result of shear stress reaching a critical threshold. However, this assumption is not verified by experimental observations. It is suggested that shear fractures are driven by a balance of shear and tensile stress, and that the transition from extension to shear fracture is controlled by the relative stress state.

A theoretical basis for continuity across stress states is provided by the Griffith theory of fracture; the theory that forms the basis of modern linear elastic fracture mechanics. Griffith theory captures the essential physical process of crack propagation, and provides an energy-based failure criterion for uniaxial tensile failure. From this theory Griffith derived a criterion for brittle failure under uniaxial stress states, at least to the degree that stress intensity factor, K, can be defined. Further modifications treat failure under compression where crack closure and friction are important, and are generalized to treat Griffith failure under triaxial stress states. It is suggested that Griffith and modified Griffith criteria predict a uniaxial tensile failure envelope for mixed tensile and compressive stress conditions that includes uniaxial tensile failure. The Griffith criteria have also been...
Ice and Its Consequences: Glaciation in the Late Ordovician, Late Devonian, Pennsylvanian-Permian, and Cenozoic Compared

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ABSTRACT

Comparison of the duration, onset conditions, and biotic response to the four Phanerozoic glaciations suggests that these are two Phanerozoic glacial modes. Late Ordovician glaciation epitomizes short-duration, high atmospheric CO₂ events, characterized by cosmopolitan faunal distributions and two episodes of catastrophic extinction. Pennsylvanian-Permian and Cenozoic glaciation typify long-duration, low atmospheric CO₂ events, characterized by abundant biogeographic differentiation and stable or rising biotic diversity. Late Devonian glaciation appears most similar to Late Ordovician glaciation: it had a short duration, Late Devonian biotas were cosmopolitan, and Late Devonian glaciation was associated with increased extinction at the Devonian-Carboniferous boundary. On the basis of biotic response, we would predict high atmospheric CO₂ levels at the time of Devonian glaciation. However, the Berner GeoCarb curve suggests relatively low atmospheric CO₂ levels in the Late Devonian.

Introduction

Paleobiogeography provides important information for the interpretation of ancient climates, particularly with regard to the strength of the pole-to-equator temperature gradient, identifying intervals of significant climatic change and determining the nature of climatic change [Ziegler et al. 1981; Raymond et al. 1989]. Because relatively few paleoclimatic models incorporate paleobiogeographic data, these data also serve to test hypotheses based on models or sedimentological and isotopic data.

Four intervals of significant continental glaciation have occurred during the Phanerozoic: Late Ordovician, Late Devonian, Pennsylvanian-Permian, and Cenozoic [Crowell 1982; Isaacson et al. 1999]. Each has affected the biota in different ways. For example, in the Late Ordovician and Late Devonian, glaciation and mass extinction occurred closely in time. Late Ordovician glaciation and extinction appear linked [Brenchley 1984; Sheehan and Corr-ough 1990; Brenchley et al. 1994, 1995]. However, in the Late Devonian, mass extinction preceded glaciation, and the two events may not be causally linked [McGhee 1996]. In the Pennsylvanian-Permian and Cenozoic, glaciation occurred during times of constant [Carboniferous-Permian marine faunas] or rising [Pennsylvanian-Permian land plants, Cenozoic biotas; Sepkoski 1981; Sepkoski et al. 1981; Raymond et al. 1990; Raymond 1996; Jablonski et al. 2003] diversity.

Differences in the biotic response to glaciation may relate to a number of factors, including the level of atmospheric CO₂ during glaciation, the latitudinal extent and location (bipolar vs. unipolar) of glaciation, the timing of glacial onset and pre-glacial conditions. Late Ordovician glaciation occurred during an interval of high atmospheric CO₂, lasted for a short interval (0.5–1 m.yr.), and affected only one pole [Crowley and Baum 1991, 1995; Brenchley et al. 1994, 1995; Gibbons et al. 2000].

In contrast, both Pennsylvanian-Permian and Cenozoic glaciation occurred during intervals with low atmospheric CO₂ and have long durations [Vevers and Powell 1987; Berner 1994; Zachos et al. 2001]. Pennsylvania-Permian glaciation lasted approximately 40 m.yr. but may not have been continuous throughout the entire interval [Vevers and Powell 1987; Woolfe 1994, Isbell et al. 2003]. Pennsylvanian-Permian glaciation began in the Southern Hemisphere, however, a growing body of evidence suggests that this glaciation eventually affected both hemispheres (table 1). Cenozoic glaciation began at about 34 Ma (in the Early Oligo-
Testing a surface tension-based model to predict the salting out of polycyclic aromatic hydrocarbons in model environmental solutions

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Abstract

Molar-based Setchenow constants (K) for six alkali and alkaline earth metal-based inorganic salts were determined at 20°C to evaluate their influence on the solubilities, and thus the aqueous activity coefficients, of three polycyclic aromatic hydrocarbons (PAHs). The six salts tested exhibited a wide range of K values, varying from 0.105 ± 0.009 M⁻¹ (for NaClO₃ and pyrene) to 129 ± 0.17 M⁻¹ (for K₂SO₄ and pyrene). In general, salting out effects with these electrolytes were observed in the order Ca²⁺ > Na⁺ > K⁺ and SO₄²⁻ > Cl⁻ > ClO₄⁻, consistent with previous reports. However, the expected salting out trend of pyrene > pyrene > naphthalene was only observed with K₂SO₄. In CaCl₂ solutions, the Kₐ value of pyrene was significantly lower than that of naphthalene. For NaCl, KCl and NaClO₃, pyrene Kₐ values were found to be lower than, but not significantly different from, those of naphthalene. Setchenow constants for all six salts were predicted using a semi-empirical, thermodynamically-based equation that relates the standard free energy change associated with transferring solutes from water to a salt solution to the difference in surface tensions between the two solutions. With this equation, predicted K values were in reasonable agreement with observed K values (generally within ±50%). Lack of better agreement between predicted and observed values likely reflects the inability of the simple surface tension model to account for all interactions among the cations, anions, PAH molecules and water molecules in the respective systems.

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Keywords: Aqueous solubility; Aqueous activity coefficient; Setchenow constant; Naphthalene; Pyrene; Anthracene; Alkali metal salts; Alkaline earth metal salts

1. Introduction

The aqueous activity coefficient is a key thermodynamic parameter governing the environmental behavior of polycyclic aromatic hydrocarbons (PAHs), a group of ubiquitous hydrophobic organic contaminants (HOCs) that continue to receive considerable attention because of their widespread occurrence, toxicity, and persistence in the environment [1-3]. Because PAH activity coefficients are inversely proportional to their solubilities in aqueous solutions [2,4], however, it is often more practical to examine how PAH aqueous solubilities affect their environmental behavior.

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Speciation of strontium in particulates and sediments from the Mississippi River mixing zone

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Abstract—Sequential extractions were performed on small amounts of particulate and sediment samples (6 to 0.5 mg) from the Mississippi River mixing zone. These leachates were analyzed for Sr concentrations and \(^{87}\text{Sr}^{86}\text{Sr}\) isotope ratio. Mn and Fe contents were also measured as they are both potential carrier phases for Sr. The largest fraction of Sr in the solid phase (particulates and sediments) was found to be present in a solid, refractory fraction (70% of total). By comparison with the corresponding sediment, particulates appear to have higher concentrations of non-refractory, labile Sr (30% vs. 15%). Carbonate components seem to play an important role as carriers for labile Sr in particulates and sediments. Changes in the composition and content of the solid phase may significantly modify both the \(^{87}\text{Sr}^{86}\text{Sr}\) isotope ratio of the total labile fractions and that of the bulk component. However, such modifications, under normal conditions, exert little measurable influence on the Sr isotope composition of the dissolved phase. Copyright © 2004 Elsevier Ltd

1. INTRODUCTION

The \(^{87}\text{Sr}^{86}\text{Sr}\) isotope ratio of marine sediments has long been used as a proxy for in situ strontium isotope studies and global climate change studies (e.g., Broecker and Peng, 1982; Burke and Denison, 1982; McKerrow et al., 1988; Raymo, 1991; Ingam and Sloan, 1992; Anderson et al., 1994; Patterson et al., 1994; Derry and France-Lanord, 1996; Huh and Edmond, 1999; Denison et al., 1998; Harris et al., 1998; Vasani, 2000). The crucial assumption that lies behind these applications is that Sr is chemically and isotopically uniform in seawater because of its long residence time (2–5 Ma) compared to the mixing time of water in the oceans (\(-10^4\) yr) (Garrison, 1989; Burke and Denison, 1982; McArthur, 1991; Henderson et al., 1994; Capo et al., 1998). However, more recent studies have suggested that small but considerable regional differences in both flux and isotopic composition of Sr can occur on timescales shorter than its residence time (Anderson et al., 1994; Derry and France-Lanord, 1996; Stoll and Schrag, 1998; de Villiers, 1999). Nonconservative behavior of Sr has been observed in estuaries (Anderson et al., 1994; Wang et al., 2001), in which various dynamic processes may control and modify the transport of fossil material to the oceans. The degree to which Sr behaves nonconservatively in estuaries needs to be better understood to interpret more fully oceanic Sr isotopic archives.

Given that Sr is mainly present in the dissolved pool of aquatic systems, and that Sr isotopes are not fractionated by any natural chemical or biologic process, the conventional view is that the \(^{87}\text{Sr}^{86}\text{Sr}\) ratio of the estuarine water column only changes by conservative mixing of distinct water masses during transport to the oceans. However, an investigation of fresh and brackish waters in the Baltic Sea (Anderson et al., 1994) has shown that Sr can be redistributed by Fe-Mn oxyhydroxides in the water column, i.e., formation of Fe-Mn oxyhydroxide particulates scavenges Sr from the dissolved load, while dissolution of Fe-Mn particulates under suboxic-anoxic conditions releases Sr back to the dissolved load. They also found that removal of Sr by Fe-Mn oxyhydroxides tends to decrease the usually large differences in \(^{87}\text{Sr}^{86}\text{Sr}\) ratio between particulate and dissolved loads. Another study on Changjiang (Yangtze River) estuarine waters (Wang et al., 2001) has shown that strong water-sediment interactions might account for observed increases in the \(^{87}\text{Sr}^{86}\text{Sr}\) ratio of the dissolved phase.

Here we perform sequential extraction analyses on particulate (\(-0.2 \mu m\) and surface sediment samples from the Mississippi River (MR) mixing zone in an attempt to investigate the inventory of Sr in solid phases and its potential influence on the behavior of Sr in the estuarine environment. Sequential extraction is a chemical technique in which a series of digestions are performed on one solid sample in an effort to extract different components of interest (e.g., the Sr adsorbed onto the Fe-Mn-oxyhydroxide component; the Sr bound to organic matter, etc.). Although the value of this technique has been debated over the past two decades because of concerns over reabsorption and incomplete selectivity (e.g., Nier and Morel, 1990), useful insights have been gained on the partitioning, association, and source-history of trace elements (Chester and Hughes, 1967; Kerssen and Forstner, 1986; Tesier and Campbell, 1991; Kruiswijk and Halbach, 1993; Golda et al., 1997; Peri et al., 1997; Dong et al., 2000). Most studies using sequential leaching techniques have been performed on either large sediment samples (1 g or more) (Kerssen and Forstner, 1986; Peri et al., 1987; Alvarez et al., 2001), or on particulates that were filtered from large volumes of water (Dodane et al., 1997; Rous et al., 2000). This study, for the first time, to our knowledge, sequentially extracts trace elements from milligram-sized samples of particulates and sediments. Although the sequential extraction of trace elements from sediments is not usually limited by the availability of sample material, the same cannot be said for particulate samples. In general, particulate samples obtained through filtration on site during field work are small, especially for saline water (often less than 20 mg/47-mm
Characterization of Cation–π Interactions in Aqueous Solution Using Deuterium Nuclear Magnetic Resonance Spectroscopy
Dongqiang Zhu,* Bruce E. Herbert, Mark A. Schultman, and Elizabeth R. Carraway

ABSTRACT
Chemical interactions of aromatic organic contaminants control their fate, transport, and toxicity in the environment. Recent molecular modeling studies have suggested that strong interactions can occur between the π electrons of aromatic molecules and metal cations in aqueous solutions and/or on mineral surfaces, and that such interactions may be important in some environmental systems. However, spectroscopic evidence for these so-called cation–π interactions has been limited to date. In this paper, cation–π interactions in aqueous salt solutions were characterized via 2H nuclear magnetic resonance (NMR) spin-lattice relaxation times (T1) and calculations of molecular correlation times (τc) for a series of perdeuterated (d4-benzenes) benzenecation complexes. The T1 values for d4-benzenes decreased with increasing concentrations of LiCl, NaCl, KCl, RbCl, CsCl, and AgNO3, with the largest effects observed in the AgNO3 and CsCl solutions. Upon normalizing τc values by solution viscosity, the spin-lattice relaxation times fit well with the relative affinities of Ag+ > Cr3+ > K+ > Rb+ > Na+ > Li+. The NMR results confirm the π complexation properties of Ag+. The ability of Ag+ to complex d4-benzenes was significantly reduced upon addition of NH3, which strongly coordinates Ag+ at high pH. Results with d4-benzenes, d4-naphthalene, d4-dichloromethane, and d4-cyclohexane in 6.6 M methanolic salt solutions confirmed that spin-lattice relaxation rates are characteristic of cation–π interactions. The relatively strong cation–π bonding observed between Ag+ and aromatic hydrocarbons probably results from covalent interactions between the aromatic π electrons and the d orbitals of Ag+, in addition to the normal electrostatic interaction.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) are a group of ubiquitous hydrophobic organic contaminants (HOCs) that continue to receive considerable attention because of their toxicity, persistence, and extensive distribution in the environment (e.g., Means et al., 1998; Kubicki et al., 1999; Schwarzenbach et al., 2002). In general, the chemical state in which PAHs are present in the environment determines their fate, transport, and overall environmental effects (e.g., Smoor, 1996; Kubicki et al., 1999; Schwarzenbach et al., 2002). At many contaminated sites, a complex suite of organic chemicals and inorganic elements are commonly present together (United States Department of Energy, 1992; National Research Council, 1994; Spiro and Stigliani, 1996). For example, polluted biogeochemical systems often contain FAHs, other HOCs (e.g., chlorinated hydrocarbons, pesticides), and heavy metals in addition to all naturally occurring chemical species (e.g., alkali and alkaline earth metals, trace metals, anions, organic matter, mineral surfaces). Characterization of the complex interactions between PAHs and cations in aqueous solution will therefore aid our understanding of the environmental fate and risk posed by these ubiquitous contaminants. Relatively strong noncovalent bonds probably form between benzene and base cations in aqueous solution due to electrosstatic attractions between the permanent quadrupole of benzene and the positively charged cations (Kumpf and Dougherty, 1993). The importance of these and other so-called cation–π interactions has been recognized for some time in biological processes, including bimolecular recognition, protein–ligand binding, and the selectivity of K+ within K+ channels in cell membranes (Miller, 1991; Dougherty, 1996; Ma and Dougherty, 1997; Gokel et al., 2001). The importance of cation–π interactions from the perspective of environmental science and engineering, however, has gone largely unexplored. For example, it is reasonable to expect that cation–π interactions may affect the distribution of PAHs between water and mineral surfaces in low organic carbon environments (Kubicki et al., 1999; Zhu et al., 2004). Cation–π interactions may also influence the relative toxicities of PAHs and heavy metals that co-exist in aqueous solution, because their association with one another would probably alter their transport across cell membranes. However, few toxicity studies of co-contaminant mixtures of heavy metals and PAHs have been performed to date (e.g., van den Hurk et al., 1998a, 1998b, 2000; Baba et al., 2001), and none of these has tried to elucidate the potential importance of cation–π effects on toxicity. Spectroscopic evidence for cation–π interactions in various organic solvents and in the gas or solid phase has been widely reported in the literature over the past several decades (e.g., Buddie et al., 1965; Sunner et al., 1981; Manakata et al., 2000; Gokel et al., 2001 and references therein). However, spectroscopic evidence for cation–π interactions in aqueous solution has been extremely limited. Instead, much of the supporting evidence for cation–π interactions in aqueous solution has come from theoretical studies. For example, formation of aqueous-phase cation–π complexes between benzene and base cations was first evaluated by Kumpf and Dougherty (1993) using an electrostatic model. Based

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Abbreviations: NMR, nuclear magnetic resonance; FAH, poly cyclic aromatic hydrocarbon; T1, spin-lattice relaxation time; τc, molecular correlation time.
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The paradox of anisotropy in electromagnetic loop-loop responses over a uniaxial half-space

Mansour al-Garni* and Mark E. Everett*

ABSTRACT

The electromagnetic loop-loop response of a uniaxial conducting half-space is derived. The solution is presented in terms of the Geomag EM34 apparent conductivity, which is based on an underlying isotropic half-space model of earth conductivity. The uniaxial medium generates an apparent conductivity that depends on the angle that the line joining the transmitter and receiver loops makes with respect to the strike of the anisotropy. Furthermore, a "paradox of anisotropy" occurs in which apparent conductivity is higher in the resistive cross-strike direction and lower in the conductive along-strike direction. The paradox is resolved once it is recognized that the receiver loop response is controlled by the conductivity in the direction of the local induced electric current flow. Accurate geological interpretation of electromagnetic loop loop data in fractured rock terrain depends on the ability of the geophysicist to recognize the counterintuitive effects of anisotropy.

INTRODUCTION

Electrical anisotropy, the variation of electrical conductivity with the direction in which it is measured, is a property of many geological formations. Electrical anisotropy in sedimentary rocks (Anderson et al., 1994) is often caused by depositional processes which generate systematic grain size variations, preferential grain alignment, interbedded sandstone laminae, or crossbedding. Alternatively, electrical anisotropy may occur in sedimentary rocks by a post-depositional process such as fracturing or diagenesis or in crystalline rocks as a consequence of fracturing, jointing, or shearing. The detection of electrical anisotropy using controlled-source electromagnetic (CSEM) methods can provide constraints on geological structure, fluid flow, and stress history in sedimentary or igneous settings (Le Maitre and Vasseur, 1981; Evrard and Costa, 1990). To achieve sound geological interpretation, it is often necessary to compute the full 3D electromagnetic response of anisotropic formations (Wang and Fang, 2001; Weiss and Newman, 2002).

A simple physical understanding of CSEM responses can be obtained, however, by recognizing that the induction process is equivalent to the diffusion of an image of the transmitter loop (TX) into the medium. The similarity of the equations governing electromagnetic induction and hydrodynamic vortex motion, first noticed by Helmholtz, leads directly to the association of the image current with a smoke ring (Lamb, 1932, 210). The latter is not "blown," but instead moves and deforms with a self-induced velocity that is generated by its own vorticity and controlled by the familiar Blot-Savart law (Arms and Hama, 1965). An electromagnetic smoke ring dissipates in a conducting medium much as the strength of a hydrodynamic eddy is attenuated by the viscosity of the host fluid (Taylor, 1918, 96–101).

In the case of a uniform isotropic half-space, the electromagnetic eddy assumes the shape of the TX loop. In frequency domain calculations, which are considered in this paper, the eddy current is concentrated at a certain "complex distance" beneath the surface (Wait, 1969). In time domain calculations, the image current moves downward and outward while diminishing in amplitude (Weihs, 1979). Hovesten and Morrison (1962) and Reid and Macne (1996) explored smoke ring diffusion in a layered isotropic earth, whereas Wang (2002) evaluated smoke ring diffusion into a vertically anisotropic, interbedded formation. All of these papers provide physical insight which greatly assist geophysicists to understand and analyze pore-scale or borehole electromagnetic responses.

A set of parallel fractures preferentially aligned in some direction over a sufficient volume of earth is a good example of a post-depositional uniaxial anisotropj. Hence, we consider a homogeneous, uniaxial anisotropic half-space comprised of parallel vertical fractures whose spacing is small compared to the exploration length scale (Figure 1). This conceptual model was also adopted by Le Maitre and Vasseur (1981) in their study of a fissured limestone formation. They evaluated the...
Duplex style and triangle zone formation: insights from physical modeling

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Abstract

Duplexes are a common feature in thrust belts at all scales. Their geometries vary significantly from antiformal stacks with significant forethrusting in the cover (e.g., southern Pyrenees, Spain) to triangle zones (e.g., foreland Canadian Rockies) to low-displacement individually spaced ramp-anticlines (e.g., Sub-Andean thrust belt, Bolivia). We present a series of physical experiments demonstrating that the strength of the décollements relative to that of the intervening and overlying rock layers plays a significant role in controlling the duplex style. The models comprise brittle layers made of dry quartz sand and décollements made of two types of viscous silicone polymers. The strength of the décollements in the models is a function of the shortening rate applied to the model. The relative strength of the décollements and surrounding rocks affects the development of active- or passive-roof duplexes (triangle zones). It also affects the amount of translation of individual thrust blocks and the spacing of thrust ramps, which in turn determines if a duplex evolves into an antiformal stack or into individually spaced ramp-anticlines. Model results indicate that specific associations of structural features form systematically under similar rheological and boundary conditions. The presence of relatively strong décollements promotes local underthrusting of the cover, individual ramp-anticlines, internal deformation of thrust sheets, low early layer-parallel shortening, and sequential transfer of foreland propagation of structures. Weak décollements promote forethrusting of the cover, antiformal stacks, coaxial growth of structures, and low internal strain, with the exception of significant early layer-parallel shortening. No underthrusting at a regional scale occurred in any model.

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Keywords: Duplex style; Triangle zone formation; Antiformal stacks

1. Introduction

The causes of the variations in thrust belt style have long been a subject of interest. As early as 1892, Bailey Willis noted that even in a single thrust belt, such as the Appalachian’s, a variety of different structures develop despite having been subjected to a similar compressional regime. Willis (1892) suggested that stratigraphic variations between or within foldbelts might be responsible for such differences. Since Willis’ work, much progress has been made in understanding the mechanical role of stratigraphy on the deformation style. We now know that many thrust belts have more than one décollement, whose location and extent are controlled by stratigraphy (e.g. Williams and Dixon, 1985; Woodward, 1985; Banks and Warburton, 1986; Price, 1986; Vergés and Martinez, 1988, etc.). The presence of multiple décollements commonly leads to duplex formation. In its most basic form, a duplex consists of thrust horsts bound by roof and floor décollements overlying a sequence of cover rocks (e.g. Boyer and Elliott, 1982; McClay, 1992). Fig. 1 illustrates several different duplex geometries in thrust belts and emphasizes the wide variability in style that is possible. Despite the abundance of duplexes within thrust belts, several questions remain relating to their formation:

1. What causes the different mechanical, and hence deformational, responses of the cover? Why do some duplexes deform by underthrusting and triangle zone formation while others merely transfer shortening to structures in the foreland (compare Fig. 1b, c and i with Fig. 1e, f and g; Fig. 2)?

2. Why have some horst blocks (lower-tier thrust sheets) undergone large translations whereas others have not (compare Fig. 1e, f, g with Fig. 1a, b and i)?

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The oxygen isotopic record of seasonality in Conus shells and its application to understanding late middle Eocene (38 Ma) climate

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Abstract. To better understand Eocene climate and the isotopic record of paleotemperature preserved in shells of the gastropod Conus, we sampled and analyzed four modern and two Eocene shells from the U.S. Gulf Coast and the Gulf of Mexico. The modern shells are from nearshore Mexico off Veracruz, offshore Texas (Stiltsville Bank), and nearshore Florida (Alligator Point). The fossil shells are of late middle Eocene (ca. 38 Ma) age from the Nodaray Branch Formation in Mississippi (U.S.A.). The four modern shells yield three distinct oxygen isotopic patterns of seasonality (asymmetrical wet-shore, steady, and irregular) representing different seasonal growth patterns and environments. The asymmetrical (wetshore) pattern occurs in the modern shell species (Stiltsville Bank) and indicates rapid spring and declining summer growth, presumably in response to increased nutrient supply and productivity associated with spring upwelling. The steady pattern indicates winter shutdown and occurs in the most northern specimens. The irregular pattern reflects seasonal freshwater input in a nearshore environment. The Eocene shells yield an asymmetrical (wet-shore) pattern suggestive of enhanced spring growth during upwelling.

Assuming a constant seawater δ18O of 0.25‰ (Lear et al., 2000), including correction for latitude (Zachos et al., 1994), oxygen isotope data yield a mean annual range of temperature (MART) for the late middle Eocene of 4–5°C and a mean annual temperature (MAT) at 21°C. Taking the depth estimation (50–100 m) into consideration, we surface temperatures are estimated to be >25°C for summer, ~20°C for winter, and MAT at 23°C. Compared with modern temperatures and isotopic palaeotemperatures of modern shells, the late middle Eocene Gulf Coast experienced warmer winter temperatures. The difference between modern and late middle Eocene climate can partly be attributed to the development of a continental cold front during the modern winter, and to the increased surface influence during the middle Eocene caused by the warmer water mass of the ocean.

Key words: Eocene, Conus, Oxygen isotopes, Carbon isotopes, Watermass, Paleotemperature

Introduction

Seasonality or mean annual range of temperature (MART) is an important element of climate and ecology (Axelrod, 1984; Greenwood and Wing, 1985; Snelson and Barri, 1992; Shinn and Morilla, 1998). For instance, MART has a significant effect on the distribution of taxa (Axelrod, 1984). One of the best methods for measuring MART in ancient environments is through oxygen isotopes.

Previous studies show that oxygen isotopes can reveal the temperatures at which calcite carbonate-secreting organisms such as bivalves, gastropods, and foraminifera lived (e.g., Enzel et al., 1993; Honke and Oba, 1972; Grossman and Ke, 1986; Kobasho et al., 2001). Methods are known to derive their shell in oxygen isotopic equilibrium with ambient water that is, without significant vital effect (Tripson et al., 1986; Zachos and Ke, 1998). For that reason, mollusk shells have frequently been used to reveal past environments over a wide temporal and spatial range (e.g., Late Cretaceous and Paleogene Laminide Rocky Mountains: Dehm and Lohmann, 2000; late Paleocene Arctic: Ries and Arthur, 1996; early middle Eocene North Atlantic region: Bambach and Soli, 2000; Holocene North Atlantic Ocean: Weinman et al., 1991).
Hydraulics of horizontal wells in fractured shallow aquifer systems

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Abstract

An analysis of groundwater hydraulic head in the vicinity of a horizontal well in fractured or porous aquifers considering confined, leaky confined, and water-table aquifer boundary conditions is presented. Solutions for hydraulic heads in both leaky confined and water table aquifers are provided. The fracture model used in this study is the standard double-porosity model. The aquifer storage is included in the formula. Solutions for the confined and unconfined conditions, fractured and porous conditions, wellbore storage, and skin effect are compared. Several findings of this study are, (1) the influence of wellbore storage and skin upon the drawdown for a fractured confined aquifer is similar to that for a porous confined aquifer, (2) aquifer storage affects the intermediate time the most by delaying the drawdown, and (3) there is a significant difference between the type curves of fractured and porous confined aquifers in most aquifer boundary conditions because of the contribution of matrix storage, and such a difference disappears at the later time.

Keywords: Horizontal well; Wellbore storage; Skin effect; Water table; Leaky confined aquifer; Fractured aquifer

1. Introduction

Horizontal well applications are one of the promising techniques in environmental remediation, water management, oil recovery, etc. In most of these applications, keeping the wellbore in contact with the targeting subsurface zone is essential. Horizontal wells offer many advantages over vertical wells because of their larger contact with the targeting aquifers.

There have been several studies about the hydraulics of horizontal wells in shallow ground water aquifers (Hantush and Papadopulos, 1962; Cleveland, 1994; Sawyer and Licausten-Dulam, 1998; Zhan et al., 2001) and in unsaturated zones (Talha, 1995; Zhan and Park, 2002). In most of these studies, the horizontal well is treated as a line sink/source and the wellbore storage and skin effects are not included. Zhan and Zlotnik (2002) derived solutions for drawdown in water table aquifers due to pumping from horizontal and inclined wells. Their solutions may be inaccurate at early time and near the well because they neglect wellbore storage and skin effects. Recently, Park and Zhan (2002) derived a solution for hydraulic head in the vicinity of horizontal wells in confined and leaky confined
Microfracture analysis of fault growth and wear processes, Punchbowl Fault, San Andreas system, California

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Abstract

Fabric and timing relations of more than 1 microfractures are used to test current hypotheses for the origin of damage along large-displacement faults by the processes of fault growth and wear. Oriented samples 0.075 m x 1 km from the Punchbowl fault surface (i.e., ultracataclastic layer) document an increase in development of preferred orientation and increase in density of microfractures towards the ultracataclastic layer, defining a zone of fault-related microfracture damage about 100 m thick. A distinct microfracture set that is perpendicular to the slip direction of the fault is present throughout the damage zone. This implies that the average orientation of the maximum principal compressive stress within the damage zone was nearly normal to the fault surface. Two additional microfracture sets are present, one oriented at low angles to the fault within meters of the ultracataclastic layer, and another low-angle set that occurs in the outermost damage zone. The preferred orientations and timing relations are most consistent with local damage accumulation from stress cycling associated with slip on a geometrically irregular, relatively weak, fault surface. Low-angle microfractures near the ultracataclastic layer also may record wear associated with the passage of earthquake ruptures, and those in the outermost damage zone may be consistent with Andersonian fault formation and subsequent fault weakening.

Keywords: Faulting, Microfracture; Fault growth; Damage zone; Earthquake; Fault mechanics

1. Introduction

Large-displacement, brittle fault zones often are characterized by one or more relatively narrow zones (several meters thick) of intense deformation, referred to as the fault zone, surrounded by a broader zone (hundreds of meters thick) of deformed rock, referred to as the damage zone, that grades outward into undeformed host rock (e.g., Witherspoon, 1977; Wallace and Morris, 1986; Chester et al., 1993). Several studies have identified an inward intensification of fractures, subsidiary faults, cataclastic particle size reduction, and mineral alteration toward the fault zone (e.g., Chester and Logan, 1986; Anders and Wiltschko, 1994; Evans and Chester, 1995; Scholz and Evans, 1998), as well as a preferred orientation of subsidiary faults and joints (Friedman, 1969; Brock and Engelder, 1977; Chester and Logan, 1983; Chester et al., 1993; Anders and Wiltschko, 1994; Brohn et al., 1996; de Leire, 1995). The purpose of this paper is to determine the orientation and distribution of microfractures, and timing of microfracture development, along the large-displacement Punchbowl fault to test current hypotheses for the origin of damage along faults by the processes of fault growth and wear.

Opening mode microfractures form in an orientation perpendicular to the local minimum compressive principal stress direction (Friedman, 1963; Engelder, 1976). Provided that statistically based sampling and analysis techniques are employed, microfracture fabrics may be used to define the paleostress conditions in the rock at the time the microfractures formed (e.g., Friedman, 1963, 1969; Langnasne and Pecker, 1980; Kowallis et al., 1987; Laubach, 1988, 1997; Blankenius, 1990; Blankenius and Siemon, 1992). The fabric of microfractures clearly related to faulting, such as those in the damage zone of a fault, may record the spatial and temporal variations in fault stress state and thus may be used to test the predictions of fault mechanical models (e.g., Vernaleone and Scholz, 1998).
Horizontal well hydraulics in leaky aquifers

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Abstract

This paper presents a general study of horizontal well hydraulics for three aquifer types: a leaky confined aquifer, a leaky water table aquifer, and a leaky aquifer under a water reservoir. Semi-analytical solutions are obtained for cases that exclude and include the aquitard storage. The type curves and derivative type curves for these different conditions are provided. A graphically integrated MATLAB program named HW_LEAK is written to facilitate numerical calculations and generation of the type curves and derivative type curves. This study shows that (1) derivative type curves are more sensitive to the aquitard parameters than the type curves, and that (2) drawdown is sensitive to the aquitard/aquifer thickness ratio and the hydraulic conductivity ratio at the intermediate and later time. Both curves are less sensitive to the aquitard/aquifer specific storage ratio, while the degree of sensitivity of the drawdown to the aquitard parameters is high in a leaky confined aquifer, moderate in a water table aquifer, and low in an aquifer under a water reservoir.

Keywords: Groundwater flow; Horizontal well; Leaky aquifer; Type curves; Derivative type curves

1. Introduction

Horizontal wells have gained significant interest among hydrogeologists and environmental scientists and engineers in recent years because of their many advantages over conventional vertical wells. The study of horizontal wells in hydrologic sciences dates back to Hantush and Papadopoulos (1962). During the last decade, groundwater flow to horizontal wells was studied in various aspects (Tarshish, 1992; Cleveland, 1994; Murdoch, 1994; Falta, 1995; Sawyer and Lienal-Dulam, 1998; Zhan, 1999; Hunt and Massmann, 2000; Kawczi, 2000; Zhan and Cao, 2000; Steward and Jin, 2001; Zhan et al., 2001; Zhan and Park, 2002; Park and Zhan, 2002; Zhan and Zlotnik, 2002).

Nevertheless, a general theory of groundwater flow to a horizontal well in a leaky aquifer is not yet available and will be the focus of this paper. New solutions for groundwater flow in a leaky confined aquifer, a leaky aquifer under a water reservoir, and a leaky water table aquifer will be presented. Both type curves and derivative type curves will be generated for these different aquifer conditions, where the type curve is defined as the dimensionless drawdown versus dimensionless time on a log–log scale, and the derivative type curve is defined as the first derivative of the dimensionless drawdown over the logarithmic dimensionless time as a function of the dimensionless time on a log–log scale. Graphically integrated MATLAB programs were written to facilitate the calculation of

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DIVISION S-2—SOIL CHEMISTRY

Sorption of Pyridine to Suspended Soil Particles Studied by Deuterium Nuclear Magnetic Resonance

Dongqiang Zhu,* Bruce E. Herbert, and Mark A. Schlutram

ABSTRACT

Spin-lattice relaxation times ($T_1$) and chemical shifts (δ) of perdeuterated pyridine (ε, γ, δ deuterium of δ-4-pyridine) in aqueous solution (e.g., water, 0.001 M benzoic acid and phenol) are found to decrease with increasing pH values. This is because the concentration distribution of the two pyridine species, protonated and unprotonated, varies with solution pH. The $T_1$ values of ε are lower than γ and δ deuterium in water and methanol compared with δ-deuterium, indicating more anisotropic molecular movements of pyridine resulting from interactions between amine and the polar solvent. Spin-spin relaxation times ($T_2$) and δ of δ-4-pyridine in aqueous suspensions of water-dispersible clay (WDC) soil components are highly pH dependent. The lowest $T_1$ and the most downfield-shifted δ compared with aqueous solution show that the strongest sorption occurs at the weak acidic condition (pH 6). The downfield shifts of δ observed in WDC suspensions are directly caused by the increased mole ratio of protonated pyridine through sorption. However, no significant changes in 5 are observed for organic free minerals (FeO$_x$-reduced WDG) and a standard dry mineral (compare with aqueous solution, indicating interactions with mineral surfaces are negligible in pyridine sorption). A sorption mechanism of cation exchange between protonated pyridine and charged sites of soil organic matter (SOM) is inferred based on the measured δ values.

Pyridine and other nitrogen-heterocyclic compounds (NHCs) have received considerable environmental attention because of their frequent existence at waste sites generated from coal gasification, shale oil extraction and pesticide production. Despite their high water solubilities (e.g., pyridine is miscible with water), sorption to soils and sediments significantly affects the fate of these chemicals, including biodegradation and chemical oxidation (Fetzer, 1998; Thomsen and Larsen, 2001). Sorption mechanisms of organic contaminants to soils and sediments have been studied mainly through batch sorption experiments (Chiao et al., 1979; Karczkoft et al., 1981; Young and Weber, 1995; Xing and Fignate, 1997). However, batch sorption experiments are unable to provide information directly on the molecular-level interactions between sorbates and sorbents. On the other hand, studies of sorption by spectroscopic techniques are very limited. Fourier transform infrared (FTIR) spectroscopy has been used to study sorption of organic chemicals to humics and soils (Martinieto et al., 1994; Landgraf et al., 1998; Suttue et al., 2001). However, observing sorbate-sorbent interactions through wavelength shifts of existing bands or appearance of new absorption bands can sometimes be ambiguous because of high background interferences (e.g., water absorbance). Compared with FTIR, nuclear magnetic resonance (NMR) spectroscopy is able to differentiate signals of interest from the others by probing isotopically enriched chemicals. High-frequency solid state NMR has been used to characterize sorption of organic chemicals to dry humics or soils. For example, chemical shifts (δ) of $^{13}$C-labeled chemicals (e.g., acetone, trichloroethylene (TCE), carbon tetrachloride) have been used to study their sorption on dry minerals, humic acids and soils (Jurkiewicz and Maciel, 1995). More recently, local motions of organic pollutants including TCE, pyridine, and benzene adsorbed on dry soil components were studied through 2H NMR using a quadrupole-echo technique (Xiong et al., 1999).

Deuterium NMR has the advantage of being sensitive to relatively weak solute interactions, and is well suited for NMR relaxation studies because deutrium relaxation is dominated by the quadrupolar relaxation mechanism (Smith, 1985). Recently, solution-phase, noncovalent interactions between perdeuterated monoaromatic compounds (e.g., phenol, pyridine, benzene) and natural humic acids have been characterized by $T_1$ measurements (Nammy and Maza, 2001). Spin-spin relaxation times or the equivalent line-broadening has also been used to characterize sorption of δ-fluorobenzene to organic materials including surfactant micelles and humic acids (Herbert and Britsch, 1997). Pyridine has an aromatic ring containing amine with a lone-pairs of electrons. This structure allows several potential mechanisms of pyridine sorption to SOM. Unprotonated pyridine can readily form H bonds with hydroxyl of functional groups (e.g., carboxyl and phenol) in SOM. On the other hand, protonated pyridine can be sorbed to soils through cation exchange. A recent study (Weber et al., 2001) proposed the cation-exchange mechanism by showing that the adsorbed $^{13}$C-labeled pyridine was nearly completely recovered after treatment.

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FTIR, Fourier transform infrared; NH, nitrogen-heterocyclic compounds; NMR, nuclear magnetic resonance; SOM, soil organic matter; $T_1$, spin-lattice relaxation times; $T_2$, spin-spin relaxation times; TCE, trichloroethylene; TOC, total organic C; WDC, water-dispersible clay; δ, chemical shifts.
Molecular-Level Investigation of Monoaromatic Compound Sorption to Suspended Soil Particles by Deuterium Nuclear Magnetic Resonance

Dongqiang Zhu,* Bruce E. Herbert, and Mark A. Schultmann

ABSTRACT

Molecular-level sorption behavior of monoaromatic compounds in suspensions of water-dispersible clay components was studied by measuring 2H nuclear magnetic resonance (NMR) spin–spin relaxation times (T2). In general, decreased T2 values indicate stronger solute–sorbent interactions and increased sorption of the solute. A decreasing trend for T2 values is the order benzene > fluorene > benzene > toluene (CD2Cl2 molely) was observed, which was probably caused by the hydrophobic effect. The T2 spin–lattice relaxation time for benzene showed a strong correlation with the pKa of the aromatic compounds (CD2Cl2 molely of toluene increased with increasing pH, whereas the trend with pH was much weaker and less consistent for fluorene and the methyl group of toluene. Conversely, no clear relationship was found between T2 values and pH for diketone compounds. These contrasting results cannot be explained by the pH-dependent self-assembly and hydrophobicity of humics. Instead, directed specific forces, including hydrogen bonding, cation–π interactions, and aromatic–aromatic interactions, are proposed between the benzene ring of monoaromatic solutes and soil organic matter (SOM). Saturates of benzene affect these interactions by varying the π electron density. When the soil fraction was treated with NaOH to remove humic and fulvic acids, T2 values for the different monoaromatic solutes were surprisingly lower compared with those for the untreated soil fraction. This result is probably caused by the increased ratio of solutes adsorbed to “hard” or “glassy” SOM components, which leads to less mobile sorbed solute molecules, after removing NaOH-extractable humics that contain more “soft” or “rubbery” SOM components.

Sorption is a key factor controlling the fate of nonionic organic chemicals (NOCs) in the environment. Due to the absence of observational data on molecular-level motions of solutes adsorbed to geosorbents in aqueous systems, hypothesized sorption mechanisms have been advanced based on indirect macroscopic observations (e.g., laboratory sorption isotherms). Previous studies have suggested that sorption of NOCs is a partitioning process between the aqueous phase and the organic phase of geosorbents, which can be quantified by an organic carbon-normalized linear sorption model (Chen et al., 1999). To account for later observations of nonlinear sorption, dual-mode sorption models have been proposed (Huang et al., 1997; Xing and Pignatello, 1997). In these models, soil organic matter (SOM) is considered to be heterogeneous and consists of “hard” and “soft” or “glasy” and “rubbery” components that exhibit different behaviors in sorption processes (Young and Weber, 1995). In general, sorption nonlinearity is thought to result primarily from “hard” or “glasy” SOM. The molecular-level mechanisms of solute–sorbent interactions in these macroscopic, phenomenological models, however, are still not clear.

It has been thought that sorption of NOCs is controlled principally by the hydrophobic effect, a combination of relatively small enthalpy effects (e.g., weak van der Waals forces resulting from dipole–dipole, induced dipole–dipole, and induced dipole–induced dipole interactions) and a substantial free energy gradient that drives the organic molecules out of the aqueous phase (Tanford, 1990; Voise and Weber, 1983). Previous research has shown, however, that aromatic chemicals can interact with polar and charged species in aqueous solution through bonding forces with energies larger than those typically exhibited by van der Waals interactions. For example, it has been reported that benzene interacts with water molecules through hydrogen bonding to form 1:1 clusters with a binding energy of about 8 kJ/mol (Suzuki et al., 1992). Spectroscopic data in that study also showed the water molecule to be located above the benzene ring with both hydrogen atoms pointing toward the π electrons of benzene. Recent spectroscopic and modeling studies have shown NH–H hydrogen bonding between aromatic compounds and amine, with interaction intensities increasing with π electron densities (Moyno et al., 2001; Mons et al., 2002). Monoaromatic compounds also have been reported to interact with base cations or charged ammonium or alkylammonia moieties through relatively strong cation–π interactions, which result from electrostatic attractions between the permanent quadrupole of a benzene ring and the cations (Kumpf and Dougerty, 1993; Ma and Dougerty, 1997; Gokel et al., 2001). Soil organic matter is known to have many functional groups (e.g., carboxyl, phenol, amine) that can interact with aromatic compounds through hydrogen bonding or cation–π interactions. Additionally, it has been known for decades that charge-transfer complexes form between π donors and π acceptors through relatively strong aromatic–aromatic interactions (X–Y kJ/mol) (Foster, 1969). Soil organic matter contains subunits of aromatic rings with high electron acceptability (e.g., quinone like structures) that may function as π acceptors under certain conditions (Melcer et al., 1989; J.J. Pignatello, personal communication, 2002). Support for specific interactions with SOM can be found from previous field studies that have observed polycyclic arom.

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Abbreviations: NMR, nuclear magnetic resonance; NOC, nonionic organic chemical; PAH, polycyclic aromatic hydrocarbon; SOM, soil organic matter; T2, spin–lattice relaxation times; T1, spin–spin relaxation times.
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Phase relations in the CH₄-H₂O-NaCl system at 2 kbar, 300 to 600°C as determined using synthetic fluid inclusions

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Abstract. Synthetic fluid inclusions in the CH₄-H₂O-NaCl system were synthesized by subjecting fractured quartz or feldspar, along with known quantities of CH₄, H₂O, and NaCl, to pressures of 2 kbar and temperatures of 300, 400, 500, and 600°C, in sealed Au capsules. Under the included P-T conditions, some of the fractures healed, trapping fluids as inclusions. Microrheometric measurements conducted on the fluid inclusions show that, at 2 kbar and 300 to 600°C, there are only two phases of fluid present in the CH₄-H₂O-NaCl system. These bulk fluid compositions fall in the high-density phase field, the high-density phase being enriched in NaCl, whereas the low-density phase is enriched in CH₄. For any given bulk composition, the degree of NaCl enrichment in the high-density phase increases, whereas the degree of CH₄ enrichment in the low-density phase decreases, as temperature increases from 300 to 600°C. Our experimental constraints on the size of the two-phase field are generally consistent with results generated using the equation of state GEOFLUIDS (available at http://www.galeval.org/gf/index.html). However, when comparing the compositions of coexisting imbibible fluids, as determined experimentally or calculated using GEOFLUIDS, we find that some relatively small but probably significant differences exist between our experiments and this equation of state. Number of figures:

1. INTRODUCTION

Fluids play an important role in many geologic processes, such as the formation of ore deposits, petroleum migration, volcanic, and active tectonic and exhumed margins, and many metamorphic processes (Scholl, 1985; 1986; Emsley and Robie, 1993; Fedo and Lachenbruch, 1994; Cornell and Halt, 1994; Hirth and Kohlstedt, 1995). In particular, species in CO₂-rich systems are the most frequently analyzed species in natural fluids (Wood, 1972, 1979, 1984; Creaser, 1993).

In this study, the experimental and analytical techniques described by Lamb et al. (1996) were used to synthesize and analyze CH₄-H₂O-NaCl fluid inclusions at 2 kbar and 300-500°C. The fluid composition of interest to this study occurs within the CO₂-H₂O-NaCl system, which defines the composition of fluids in a wide range of geologic environments. Whereas, CH₄-rich fluids clearly have a wide restricted occurrence (e.g., H₂O-NaCl fluids, anhydrite-bearing fluids), these fluids have been reported from a variety of geologic environments, including high-grade magmatic to very low-grade metamorphic rocks of the central Alps (Oudin et al., 1972) and central Appalachians (Klohn and van den Kerkhof, 1991). Rocks from higher-grade contact aureoles containing textural evidence also contain methane-bearing fluids (Klohn and van den Kerkhof, 1991; Heinle, 1993; as well as acicular rocks such as the Shoshana intrusive [Furen et al., 1922]; and some geologic provinces [Koeller, 1995], the results of this study should have implications for understanding CH₄-rich fluids from higher temperature environments. In addition, the results should provide input for deciding whether or not models in the larger C-O-H-NaCl system (e.g., Duru et al., 1992a, 1992b, 1993).

It is well-documented that synthetic fluid inclusions can be used to determine P-V-T properties and phase relations of fluids and to understand the behavior of natural fluid inclusions. Scholl and Oxburgh (1985) first documented that synthetic fluid inclusions could be employed to determine composition of fluids at elevated temperatures and pressures. Similar techniques have also been used to determine phase volumes as a function of P and T and to determine phase relations for a molecule of fluids and fluid mixtures. Studies of this type include work with pure fluids such as H₂O (Bodnar and Stewart, 1985; Zhang and Frantz, 1987), as well as binary and ternary H₂O-CO₂ systems such as H₂O-CO₂-NaCl (Bodnar et al., 1985; Zhang and Frantz, 1987), H₂O-CO₂-NaCl (Schott and Frantz, 1987; Stewart et al., 1986), and H₂O-CO₂-NaCl (Schott et al., 1987). Binary fluid systems such as H₂O-CO₂ (Stewart and Bodnar, 1991), and H₂O-CO₂ (Schott and Frantz, 1987; as well as ternary systems involving solutes such as H₂O-CO₂-NaCl (Frantz et al., 1994); Schott et al., 1990; and Schott and Frantz, 1992) have also been investigated using synthetic fluid inclusions. These studies have generally produced data in agreement with those obtained using other techniques (e.g., Bodnar and Stewart, 1985; Zhang and Frantz, 1987; Hirth and Linford, 1989; Stewart and Bodnar, 1991).

Lamb et al. (1996) used synthetic fluid inclusions to determine the phase relations in the CH₄-H₂O-NaCl system at 1 kbar and temperatures in the range 400 to 600°C. Microrheometric examination of the fluid inclusions, combined with microrheometric measurements, provided the data necessary to identify the position of the solution between the phase and two-phase fields and to define the compositions of the coexisting fluids at the two-phase field. In the study described here, the range of conditions has been expanded to make pressure and slightly lower temperatures. Phase relations in the CH₄-H₂O-NaCl system were determined using synthetic fluid inclusions produced...
Hydraulics of a finite-diameter horizontal well with wellbore storage and skin effect

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Abstract

We have obtained solutions of groundwater flow to a finite-diameter horizontal well including wellbore storage and skin effect in a three-dimensionally anisotropic leaky aquifer. These solutions improve previous line source solutions by considering realistic well geometry and offer better description of drawdown near the horizontal well. These solutions are derived on the basis of the separation of the source and the geometric functions. The source function is analyzed using Laplace transformation, and the geometric function is derived based on the method of superposition. The solution in a confined aquifer is derived as a special case of the solution in a leaky aquifer. The graphically integrated computer program FINHOW is written to generate type curves of groundwater flow to a finite-diameter horizontal well. The influences of the finite diameter of the well, the wellbore storage, the skin effect, the leakage parameter, and the aquifer anisotropy is thoroughly analyzed. The well diameter, the wellbore storage, the skin effect, and the aquifer anisotropy substantially affect the near-well early time drawdown if compared to the line source solution, but they have negligible influence upon the far field or late time drawdown. This research provides a better tool for interpreting finite-diameter horizontal well pumping tests.

1. Introduction

Horizontal wells have screen sections parallel to the horizontal directions. These wells have been widely used in petroleum engineering [21,26,44], and agricultural and civil engineering [15,31] in the past. They have gained significant interests among hydrogeologists, environmental scientists, and engineers in recent years [11,18,43,50–52]. Horizontal wells have advantages that are irreplaceable by vertical wells at some circumstances. For instance, they can be used at sites where ground surfaces are obstructed by permanent structures such as buildings, highways, railways, wetlands, landsfills, etc.; they can have great contact areas with the thin ground water aquifers; they can be effective in recovering thin layer contaminants; they can perform better recovery in vertically fractured aquifers, etc.

Hantush and Papadopulos [11] have initially investigated the hydraulics of a collector well, which is a series of horizontal wells distributed in a horizontal plane. Petroleum engineers have studied fluid flow to hori-

zontal wells in oil and gas reservoirs [7,12,42]. In recent years, hydrogeologists have studied hydraulics of horizontal wells in shallow ground water aquifers [5,43,50–52]. In most of these studies, the horizontal well is treated as a line source and the well storage and skin effect are not included. The wellbore storage refers to water initially stored inside the well; the skin effect refers to the alteration of hydraulic conductivity at a thin layer immediately outside the wellbore during the well-installation process. The well skin serves as a barrier separating the wellbore from the aquifer.

Extensive studies on hydraulics of finite or large diameter vertical wells, including the wellbore storage and skin effect, have been reported before [3,4,9,10,22,27,28,30,34,36,49]. The analytical solution for the drawdown produced by a large-diameter vertical well including fluid storage capacity was first presented by Van Everdingen and Hurst [49] in petroleum, and by Papadopulos and Cooper [36] in groundwater literature. Those studies have been extensively applied to oil and gas well problems later [1,19,38–40,47]. Large diameter wells have been used for hydrological applications is homogeneous aquifers [20,27,28,36] and in heterogeneous aquifers [17]. They have been applied in confined aquifers [36,45], leaky aquifers [25,27], and water table aquifers [28].

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Sources of alluvium in a coastal plain stream based on radionuclide signatures from the $^{238}\text{U}$ and $^{232}\text{Th}$ decay series

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[1] Discerning alluvial sources and their change over time or distance is a fundamental question in hydrology and geology, often critical in identifying impacts of human and natural perturbations on fluvial systems. Surfaces of upland interfluves and subsoils, sources of alluvium in the lower Loco Bayou basin, Texas, were distinguished using the isotope ratios $^{226}\text{Ra}/^{232}\text{Th}$, $^{228}\text{Ra}/^{232}\text{Th}$, and $^{230}\text{Th}/^{232}\text{Th}$. Channel alluvium indicates a transition from interfluve surface to subsoil sources during flood (subsoil ~34% to ~91%, over about 8 km) and bank-full stages (subsoil ~9% to ~74%, over about 12 km), with distance downstream. These results indicate strong coupling between hillslope and channel processes, reflecting land use change from forested to agricultural, concentrated in lower Loco Bayou. This methodology shows that sediment sources can be differentiated based upon landscape placement where lithologic contrast is absent. The geochemistry, long half-lives, and fractionation of $^{238}\text{U}$ and $^{232}\text{Th}$ decay series radionuclides during pedogenic and fluvial processes in humid climates suggest that these methods are applicable in a wide variety of fluvial systems. INDEX TERMS: 1060 Geochernistry: Isotopic composition/chemistry; 1803 Hydrology: Anthropogenic effects; 1815 Hydrology: Erosion and sedimentation; 1834 Hydrology: Geomorphology (0625); KEYWORDS: natural radionuclides, fingerprinting, alluvium, source apportioning


1. Introduction

[2] Discerning the origin of fluvial sediment and source fluctuations over time is a critical question in hydrology, geology, geomorphology, and water resource management. Knowledge of fluvial sediment sources is important in many fields of environmental science, as sediment affects the fate and transport of pollutants [Macklin et al., 1997; Marcus et al., 2001], water quality [Langlois et al., 1997; Swank et al., 2001], ecological health and diversity [Rice et al., 2001; Zajac and Whitlatch, 2001], and reservoir design and sustainability [Halen-Garces et al., 1999], to name just a few. In the U.S., for example, many specific water quality issues such as section 305 (Clean Water Act), nonpoint source pollution assessments and the monitoring of total maximum daily loads for sediment and sorbed pollutants may hinge directly on determining the source of sediment delivered to streams. Sources of sediment to river systems are not simple to measure or model at any scale. The case study presented here focuses on the development of methods for the delineation and quantification of sources of alluvial sediments in transient storage within an east Texas fluvial system. Spatial and temporal variations, both natural (climate and tectonics) and anthropogenic (agriculture and urbanization), influence the source flux, transport rate and residence time of alluvial sediments, which complicates field-based or mathematical attempts to address this question [Robertson and Church, 1986; Kelsey et al., 1987; Hoyn, 1992].

1.1. Previous Research

[3] Sources of alluvium to rivers have been assessed using a variety of tools including soil and sediment mineralogy [Phillips, 1992; Woodward et al., 1992], combinations of lithogenic and atmospheric radionuclides [Olley et al., 1993, 1997], heavy metals [Passmore and Macklin, 1994; Lecce and Pavlovsky, 2001], petrology [Schniedermann, 1995], and mineral magnetics [Cattie et al., 1998], and combinations of fallout radionuclides and geochemistry (C and N) [Negle and Richer, 1999]. While this list is more illustrative rather than exhaustive, the common theme is that sediment source areas within a watershed have different physico-chemical, mineralogical and other properties that may allow for an estimate of the relative contribution of these sources to stream sediments.

[4] Fallout radionuclides ($^{137}\text{Cs}$, $^{140}\text{Sr}$, $^{7}\text{Be}$) have been used to investigate soil erosion [Quine and Wadding, 1991; Branca andVoltaggio, 1993; Zhang et al., 1998], fluvial sediment yields and sediment budgets [Allison et al., 1998; Wadding, 1999], and resuspension and residence times [Wadling et al., 1998; Lowitt et al., 1999]. Radionuclides in the $^{238}\text{U}$ and $^{232}\text{Th}$ decay series have also been used to address a range of problems in geology and fluvial geo-
Vapor Flow to Horizontal Wells in Unsaturated Zones

Hongbin Zhan* and Euangyu Park

ABSTRACT
We have solved the linearised vapor flow equation in a transient, three-dimensional form for a horizontal-well sink in an unsaturated zone. This is done by solving the vapor flow to a point sink first, then superposing the point-sink solution along a finite length of the horizontal-well axis to obtain the solution of flow to a horizontal-well sink. Vapor-pressure distributions near a horizontal well are provided for both covered and uncovered ground surface cases. A computer program VFD (available from our website) is used to calculate the vapor pressure and to generate the type curves of vapor-pumping tests. The derived solution is used to calculate the specific vapor flux and the total vapor-mass flux across the uncovered ground surface. The type curves at early times for a covered surface case are influenced by the location of the monitoring wells and vertical anisotropy of the unsaturated zone. These type curves converge to the vertical-well Theis curve at late time. The type curves for an uncovered surface case are significantly different from the Theis curve during the entire pumping time, and are similar to the type curves of leaky aquifiers. The steady-state contour maps of mass fluxes across the uncovered surfaces are plotted. The transient mass flux rate converges exponentially to the horizontal-well pumping rate, independent of the horizontal-well elevation. The derived analytical and numerical solutions are useful for assessing the performance of soil-vapor extraction, biocventing, enhanced bioremediation, air sparging, and for interpreting vapor-pumping tests.

Vapor flow is an important subject in soil physics and soil-remediation technologies. An early study of vapor flow in a gas reservoir was carried out by Munkat and Boset (1931). Soil scientists have utilized injected air and pressure measurements to evaluate soil permeability (Kirkham, 1946; Evans and Kirkham, 1949; Grover, 1955; Tanner and Wengel, 1957). In recent years, numerous studies have been done regarding soil venting, biocventing, calcium carbonate removal, air sparging, and soil-vapor extraction that have become common methods for treating subsurface contaminated soils (Baehr, et al., 1989; Johnson et al., 1990; USEPA, 1992; Falta, 1995; Hunt and Massmann, 2000). Previous studies of vapor flow are mostly limited to vertical wells (Massmann, 1999; McWhorter, 1990; Baehr and Hult, 1991; Cho and DiGiulio, 1992; Shan et al., 1992; Cho, 1993; Beckett and Huntley, 1994; Baehr and Jos, 1995). Illman and Neuman (2000) reported a type curve interpretation of single-hole pneumatic tests for vertical and slanted wells in unsaturated fractured rocks. They also presented type-curve interpretation of cross-hole pneumatic injection tests conducted at the same site (Illman and Neuman, 2001); however, recently work has been done on horizontal wells.

Horizontal wells have been found to be effective tools for collecting contaminated groundwater and vapor from the subsurface because of their large screen length and large contact area with groundwater and vapor (Cleveland, 1994; Falta, 1995; Sawyer and Liuellb Dunham, 1998; Zhou, 1999; Hunt and Massmann, 2000; Zhou and Cao, 2000). Horizontal wells have been extensively used for oil and gas production also because of the large contact area with oil or gas (Good and Thamban, 1987; Daviau et al., 1988; Erkan et al., 1988; Roia and Carvalho, 1989). In addition, horizontal wells are often used at sites where vertical wells cannot be used because of the difficulty in accessing the sites. The environmental applications of horizontal wells for vapor extraction are significant because of their advantages over vertical wells. However, vapor flow to a horizontal well is rarely studied and the knowledge base for understanding vapor extraction through horizontal wells is limited. Present available references include an analytical study by Falta (1995) and a recent investigation of vapor flow to a leaky trench by Hunt and Massmann (2000). Falta's (1995) solution is two-dimensional since the well is assumed to be infinitely long. Hunt and Massmann's (2000) solution is steady-state.

A general transient, three-dimensional solution of vapor flow to a finite length horizontal well in an anisotropic unsaturated zone does not exist now. This solution is very useful for understanding dynamics of vapor flow in the unsaturated zone, developing vapor extraction remediation plans, and interpreting vapor pumping and injecting tests using horizontal wells. In this paper, we will provide such a general solution of transient vapor flow to a finite-length horizontal well in a three-dimensionally anisotropic unsaturated zone. We consider two practical ground surface boundaries: a covered surface and an uncovered surface. If the ground surface is covered with impermeable material, it is treated as a no-flow boundary for vapor. If the ground surface is uncovered, it is treated as a boundary of constant pressure equal to atmospheric pressure. The top of the capillary fringe underneath the unsaturated zone serves as the lower no-flow boundary for vapor.

Mathematical Modeling

Problem Description
Figure 1 is a diagram of a finite-length horizontal well, underneath a covered surface. The origin of the coordinate system is at the lower boundary. The z-axis is through the center of the horizontal well and the x-axis is parallel to the well axis. The distance from the horizontal well to the lower boundary is z and the distance from surface to the lower boundary is d. The well screen length is L.

As in previous studies (Falta, 1995), the following assumptions are adopted: (i) the medium is homoge-
C.6. Graduate Program Assessment Plan
Mission/Purpose

The Department of Geology and Geophysics is dedicated to the scientific study of all aspects of the solid Earth, from fundamental processes that shape it to knowledge that benefits society. The purpose of the M.S. in Geology program is to produce graduates with a strong foundation in the fundamentals of a particular sub-discipline of geology, and the ability to conduct and communicate a directed research project. The M.S. is the most common entry degree to a career in energy and environmental science, but students will also be prepared for further study in PhD programs.

Student Learning Outcomes, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans

O 1: Original research
Gradsuates will be able to conduct original research under the direction of an advisor.

Associations:
General Education or Core Curriculum:

2 Demonstrate critical analysis skills

Related Measures:

M 1: Publication of research results
The graduate committee will collect data on student publishing.

Source of Evidence: Existing data

Achievement Target:
40% of graduating students will submit a manuscript for publication before leaving TAMU
75% of all M. S. theses will result in manuscripts submitted for publication

Findings (2008-2009) - Achievement Target: Not Met
None of the 4 MS graduates in 2008-09 submitted manuscripts before they graduated.

M 2: Visibility at professional meetings
The graduate committee will collect data on student presentations at national conferences and workshops.

Source of Evidence: Existing data

Achievement Target:
75% of students will participate in a research presentation at a professional meeting

Findings (2008-2009) - Achievement Target: Partially Met
50% of the MS graduates in 2008-09 had research presentations at a professional meeting before they graduated.

O 2: Specialized knowledge in chosen area of geology
Graduates will have a foundation in the theory and application of at least one subdiscipline of geology

Associations:

General Education or Core Curriculum:

1 Master the depth of knowledge required of a discipline

Related Measures:

M 4: Specialized knowledge
The thesis proposal and final examinations will test the student's knowledge in areas required of their research topic.

Source of Evidence: Senior thesis or culminating major project

Achievement Target:
100% of graduates will satisfy examination committee

Findings (2008-2009) - Achievement Target: Met
All students graduating in 2008-09 satisfied the examination committee.

O 3: Effective Communication
Graduates will be able to communicate their findings in written reports and in oral
presentations

**Associations:**

General Education or Core Curriculum:

3 Communicate effectively in writing and speaking

**Related Measures:**

M 1: Publication of research results
The graduate committee will collect data on student publishing.

Source of Evidence: Existing data

**Achievement Target:**

40% of graduating students will submit a manuscript for publication before leaving TAMU

75% of all M. S. theses will result in manuscripts submitted for publication

**Findings (2008-2009) - Achievement Target: Not Met**

None of the 4 MS graduates in 2008-09 submitted manuscripts before they graduated.

**Related Action Plans:**

Add a writing-intensive graduate course

The department has added a writing-intensive graduate course, in hopes of encouraging graduate students to begin preparing publications earlier during their tenure. The first such course, which covered the mechanics of writing abstracts, manuscripts, reports, and grants, was offered during Spring 2009, and may be offered each semester in the future.

For more information, see the Action Plan Details section of this report.

M 2: Visibility at professional meetings
The graduate committee will collect data on student presentations at national conferences and workshops.

Source of Evidence: Existing data

**Achievement Target:**

75% of students will participate in a research presentation at a professional meeting

**Findings (2008-2009) - Achievement Target: Partially Met**

50% of the MS graduates in 2008-09 had research presentations at a professional meeting before they graduated.

**Other Outcomes/Objectives, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans**

O 4: Internship

The Department will encourage graduate students to take internships with energy companies, environmental firms, or government laboratories
**Associations:**

**Institutional Priorities:**

4. Expand off-campus opportunities, such as internships, study-abroad, and service-learning.

**Related Measures:**

**M 3: Student Exit and Entrance surveys**
The Department will conduct surveys of incoming students and finishing students (prior to their thesis defense), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**

50% of MS students will take a summer internship in an energy company, environmental firm, or government laboratory

**Findings (2008-2009) - Achievement Target: Met**

Of the students completing the survey, 75% held summer internships during their studies.

**O 5: Job Placement**

Graduates will be competitive for jobs in industry, and top Ph.D. programs

**Strategic Plans:**

Texas A&M University

2 Strengthen our graduate programs.

**Related Measures:**

**M 3: Student Exit and Entrance surveys**
The Department will conduct surveys of incoming students and finishing students (prior to their thesis defense), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**

80% of students will complete both surveys

**Findings (2008-2009) - Achievement Target: Partially Met**
The survey forms for 2008-09 did not distinguish between Geol MS, Geol PhD, Geop MS, or Geop PhD. Of the graduating students 4/12 = 33% completed the survey. 100% of those completing the survey obtained positions as professional geologists/geophysicists.

**M 5: Graduate tracking**
The Department will collect data on student’s career path.

Source of Evidence: Existing data

**Achievement Target:**

90% of graduates will obtain jobs as professional geologists in industry or enter competitive graduate PhD programs.

**Findings (2008-2009) - Achievement Target: Met**
The survey forms for 2008-09 did not distinguish between Geol MS, Geol PhD, Geop MS, or Geop PhD. Of all students completing the survey, 100% accepted positions as professional geologists/geophysicists.

### Details for Action Plans Established This Cycle

#### Add a writing-intensive graduate course

The department has added a writing-intensive graduate course, in hopes of encouraging graduate students to begin preparing publications earlier during their tenure. The first such course, which covered the mechanics of writing abstracts, manuscripts, reports, and grants, was offered during Spring 2009, and may be offered each semester in the future.

- **Priority:** High
- **Target Date:** 01/2009
  - First graduate W course was offered during Spring 2009, and may be offered each semester in the future.

### Analysis Answers

#### For Student Learning Outcomes: Based on the assessment findings, what changes will be made to enhance student learning?

Students will be encouraged to enroll in the new graduate-level W course.

#### For Program Outcomes: What changes will be made to the program as a result of your assessment of other program outcomes?

Not Applicable

#### Assessment Process: Reflecting on the program’s assessment process, what changes do you intend to make to the assessment plan?

We will contact students individually during their final semester and encourage them to provide information needed in the assessment process.

### Annual Reports

#### Program Contributions

It is notable that all of our graduates at the MS and PhD levels during this cycle obtained permanent employment as professional geoscientists.

### Detailed Assessment Report

**2008-2009 Geology, PhD**
Mission/Purpose
The Department of Geology and Geophysics is dedicated to the scientific study of all aspects of the solid Earth, from fundamental processes that shape it to knowledge that benefits society. The purpose of the Ph.D in Geology program is to produce graduates with a strong expertise in one or more specialty areas within geology and related disciplines, and the ability to lead original research projects. Graduates will be prepared for academic teaching and research positions, and government and industry research.

Student Learning Outcomes, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans

O 1: Original research
Graduates will develop expertise in a subdiscipline of geology, and be able to conduct independent original research in that area.

Associations:
General Education or Core Curriculum:
2 Demonstrate critical analysis skills

Related Measures:

M 1: Publication of research results
The graduate committee will collect data on student publishing.
Source of Evidence: Existing data

Achievement Target:
90% of graduating students will have at least one manuscript in publication or submitted for publication at the time of their defense.
50% of graduating students will have at least two manuscripts in publication or submitted for publication at the time of their defense.

Findings (2008-2009) - Achievement Target: Not Met
50% of the PhD graduates in 2008-09 had 1 manuscript submitted or published at the time of defense; 0% had 2 manuscripts submitted or published.

M 2: Visibility at professional meetings
The graduate committee will collect data on student presentations at national conferences and workshops.
Source of Evidence: Existing data

Achievement Target:
75% of students will participate in a research presentation at a professional meeting, on average, at least once per year.

Findings (2008-2009) - Achievement Target: Met
The 2008-09 PhD graduates averaged 3.5 presentations at professional meetings during their tenure.

O 2: Broad background
Graduates will have enough background in supporting specialties and other fields
to relate their own discipline to broader questions in geology

**Associations:**

**General Education or Core Curriculum:**

1. Master the depth of knowledge required of a discipline

**Related Measures:**

**M 4: Demonstrated breadth**

The graduate committee will collect data on qualifying exams.

Source of Evidence: Existing data

**Achievement Target:**

75% of students taking their preliminary exam will be deemed by their committee to have no significant deficiencies in background that require further coursework or remedial study.

**Findings (2008-2009) - Achievement Target: Not Met**

Data are not available. Tracking of Prelims and the results will have been done at the department level on a case-by-case basis.

**Related Action Plans:**

**Monitor prelim results**

Recommendations for additional coursework made by prelim committees are not usually part of the official report. They will have to be monitored at the department level.

For more information, see the Action Plan Details section of this report.

**O 3: Effective Communication**

Graduates will be able to communicate their findings in written reports and in oral presentations

**Associations:**

**General Education or Core Curriculum:**

3. Communicate effectively in writing and speaking

**Related Measures:**

**M 1: Publication of research results**

The graduate committee will collect data on student publishing.

Source of Evidence: Existing data

**Achievement Target:**

90% of graduating students will have at least one manuscript in publication or submitted for publication at the time of their defense.

50% of graduating students will have at least two manuscripts in publication or submitted for publication at the time of their defense.

**Findings (2008-2009) - Achievement Target: Not Met**

50% of the PhD graduates in 2008-09 had 1 manuscript submitted or published at the time of defense; 0% had 2 manuscripts submitted or published.
Related Action Plans:

Add a writing-intensive graduate course
The department has added a writing-intensive graduate course, in hopes of encouraging graduate students to begin preparing publications earlier during their tenure. The first such course, which covered the mechanics of writing abstracts, manuscripts, reports, and grants, was offered during Spring 2009, and may be offered each semester in the future.
For more information, see the Action Plan Details section of this report.

M 2: Visibility at professional meetings
The graduate committee will collect data on student presentations at national conferences and workshops.
Source of Evidence: Existing data

Achievement Target:
75% of students will participate in a research presentation at a professional meeting, on average, at least once per year.

Findings (2008-2009) - Achievement Target: Met
The 2008-09 PhD graduates averaged 3.5 presentations at professional meetings during their tenure.

Other Outcomes/Objectives, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans

O 4: Internship
The Department will encourage graduate students to take internships with energy companies, environmental firms, or government laboratories

Associations:

Institutional Priorities:

4 Expand off-campus opportunities, such as internships, study-abroad, and service-learning.

Related Measures:

M 3: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and finishing students (prior to their dissertation defense), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
35% of PhD students will take a summer internship in an energy company, environmental firm, or government laboratory

Findings (2008-2009) - Achievement Target: Met
The interview forms for 2008-09 did not distinguish between Geol and Geop students nor between MS and PhD. Of all students graduating, 75% held a summer internship during their tenure.
O 5: Job Placement
Graduates will be competitive for highly-sought research and leadership positions in industry, and faculty positions in academia.

**Strategic Plans:**
- Texas A&M University
- Strengthen our graduate programs.

**Related Measures:**

M 3: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and finishing students (prior to their dissertation defense), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**
80% of students will complete both surveys

**Findings (2008-2009) - Achievement Target: Partially Met**
The survey forms for 2008-09 did not distinguish between Geol MS, Geol PhD, Geop MS, or Geop PhD. Of the graduating students 4/12 = 33% completed the survey. 100% of those completing the survey obtained positions as professional geologists/geophysicists.

M 5: Graduate tracking
The Department will collect data on students career path.

Source of Evidence: Existing data

**Achievement Target:**
90% of graduates will attain jobs at an academic department or in a government or industry research lab.

**Findings (2008-2009) - Achievement Target: Met**
The survey forms for 2008-09 did not distinguish between Geol MS, Geol PhD, Geop MS, or Geop PhD. Of the graduating students 4/12 = 33% completed the survey. 100% of those completing the survey obtained positions as professional geologists/geophysicists.

**Details for Action Plans Established This Cycle**

**Add a writing-intensive graduate course**
The department has added a writing-intensive graduate course, in hopes of encouraging graduate students to begin preparing publications earlier during their tenure. The first such course, which covered the mechanics of writing abstracts, manuscripts, reports, and grants, was offered during Spring 2009, and may be offered each semester in the future.

**Priority:** High

**Target Date:** 01/2009
Course was first taught during Spring 2009

**Monitor prelim results**
Recommendations for additional coursework made by prelim committees are not usually part of the official report. They will have to be monitored at the department level.

Priority: High
Target Date: 01/2009
W course first offered Spring 09

Analysis Answers

For Student Learning Outcomes: Based on the assessment findings, what changes will be made to enhance student learning?

Students will be encouraged to enroll in the new graduate-level W course.

For Program Outcomes: What changes will be made to the program as a result of your assessment of other program outcomes?

Not Applicable

Assessment Process: Reflecting on the program’s assessment process, what changes do you intend to make to the assessment plan?
1) We will contact students individually during their final semester and encourage them to provide information needed in the assessment process.
2) We will closely monitor the requests to schedule preliminary exams, and request information about the committee’s recommendations.

Annual Reports

Program Contributions
It is notable that all of our graduates at the MS and PhD levels during this cycle obtained permanent employment as professional geoscientists.
Detailed Assessment Report
2008-2009 Geophysics, MS

Mission/Purpose
The Department of Geology and Geophysics is dedicated to the scientific study of all aspects of the solid Earth, from fundamental processes that shape it to knowledge that benefits society. The purpose of the M.S. in Geophysics program is to produce graduates with a strong foundation in the fundamentals of a particular sub-discipline of geophysics, and the ability to conduct and communicate a directed research project. The M.S. is the most common entry degree to a career in energy and environmental science, but students will also be prepared for further study in PhD programs.

Student Learning Outcomes, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans

O1: Original research
Graduates will be able to conduct original research under the direction of an advisor.

Associations:
General Education or Core Curriculum:
2. Demonstrate critical analysis skills
Related Measures:

M 1: Publication of research results
The graduate committee will collect data on student publishing.

Source of Evidence: Existing data

Achievement Target:
40% of graduating students will submit a manuscript for publication before leaving TAMU
75% of all M. S. theses will result in manuscripts submitted for publication

Findings (2008-2009) - Achievement Target: Not Met
Of 2 MS graduates who reported publications, neither had submitted a manuscript before leaving.

M 2: Visibility at professional meetings
The graduate committee will collect data on student presentations at national conferences and workshops.

Source of Evidence: Existing data

Achievement Target:
75% of students will participate in a research presentation at a professional meeting

Findings (2008-2009) - Achievement Target: Partially Met
Of 2 MS graduates who reported publications, 1 had participated in a research presentation at a professional meeting.

O 2: Fundamental knowledge in chosen area of geophysics
Graduates will have a foundation in the theory and application of at least one subdiscipline of geophysics (seismology, electromagnetism, geodynamics)

Associations:

General Education or Core Curriculum:
1 Master the depth of knowledge required of a discipline

Related Measures:

M 4: Specialized knowledge
The thesis proposal and final examinations will test the student's knowledge in areas required of their research topic.

Source of Evidence: Senior thesis or culminating major project

Achievement Target:
100% of graduates will satisfy examination committee

Findings (2008-2009) - Achievement Target: Met
100% of students satisfied the examination committee.

O 3: Effective Communication
Graduates will be able to communicate their findings in written reports and oral presentations

Associations:
General Education or Core Curriculum:

3 Communicate effectively in writing and speaking

Related Measures:

M 1: Publication of research results
The graduate committee will collect data on student publishing.

Source of Evidence: Existing data

Achievement Target:
40% of graduating students will submit a manuscript for publication before leaving TAMU
75% of all M. S. theses will result in manuscripts submitted for publication

Findings (2008-2009) - Achievement Target: Not Met
Of 2 MS graduates who reported publications, neither had submitted a manuscript before leaving.

Related Action Plans:
Add a writing-intensive graduate course
The department has added a writing-intensive graduate course, in hopes of encouraging graduate students to begin preparing publications earlier during their tenure. The first such course, which covered the mechanics of writing abstracts, manuscripts, reports, and grants, was offered during Spring 2009, and may be offered each semester in the future.
For more information, see the Action Plan Details section of this report.

M 2: Visibility at professional meetings
The graduate committee will collect data on student presentations at national conferences and workshops.

Source of Evidence: Existing data

Achievement Target:
75% of students will participate in a research presentation at a professional meeting

Findings (2008-2009) - Achievement Target: Partially Met
Of 2 MS graduates who reported publications, 1 had participated in a research presentation at a professional meeting.

Other Outcomes/Objectives, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans

O 4: Internship
The Department will encourage graduate students to take internships with energy companies, environmental firms, or government laboratories

Associations:

Institutional Priorities:

4 Expand off-campus opportunities, such as internships, study-abroad,
and service-learning.

Related Measures:

M 3: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and finishing students (prior to their thesis defense), to determine their expectations, goals, achievement, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
50% of MS students will take a summer internship in an energy company, environmental firm, or government laboratory.

Findings (2008-2009) - Achievement Target: Met
The interview forms for 2008-09 did not distinguish between Geol and Geop students nor between MS and PhD. Of all students graduating, 75% held a summer internship during their tenure.

O 5: Job Placement
Graduates will be competitive for jobs in industry, and top Ph.D. programs

Strategic Plans:
- Texas A&M University
  - Strengthen our graduate programs.

Related Measures:

M 3: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and finishing students (prior to their thesis defense), to determine their expectations, goals, achievement, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
80% of students will complete both surveys.

Findings (2008-2009) - Achievement Target: Partially Met
The survey forms for 2008-09 did not distinguish between Geol MS, Geol PhD, Geop MS, or Geop PhD. Of the graduating students 4/12 = 33% completed the survey.

M 5: Graduate tracking
The Department will collect data on student’s career path.

Source of Evidence: Existing data

Achievement Target:
90% of graduates will obtain jobs as professional geophysicists in industry or enter competitive graduate PhD programs.

Findings (2008-2009) - Achievement Target: Met
The survey forms for 2008-09 did not distinguish between Geol MS, Geol PhD, Geop MS, or Geop PhD. Of all students completing the survey, 100% accepted positions as professional geologists/geophysicists.
Details for Action Plans Established This Cycle

Add a writing-intensive graduate course

The department has added a writing-intensive graduate course, in hopes of encouraging graduate students to begin preparing publications earlier during their tenure. The first such course, which covered the mechanics of writing abstracts, manuscripts, reports, and grants, was offered during Spring 2009, and may be offered each semester in the future.

Priority: High
Target Date: 01/2009
Spring semester 2009

Analysis Answers

For Student Learning Outcomes: Based on the assessment findings, what changes will be made to enhance student learning?

Students will be encouraged to enroll in the new graduate-level W course.

For Program Outcomes: What changes will be made to the program as a result of your assessment of other program outcomes?

Not Applicable

Assessment Process: Reflecting on the program’s assessment process, what changes do you intend to make to the assessment plan?

We will contact students individually during their final semester and encourage them to provide information needed in the assessment process.

Annual Reports

Program Contributions

It is notable that all of our graduates at the MS and PhD levels during this cycle obtained permanent employment as professional geoscientists.

Detailed Assessment Report

2008-2009 Geophysics, PhD

Mission/Purpose

The Department of Geology and Geophysics is dedicated to the scientific study of all aspects of the solid Earth, from fundamental processes that shape it to knowledge that benefits society. The purpose of the Ph.D in Geophysics program is to produce graduates with a strong expertise in one or more specialty areas within
geophysics and related disciplines, and the ability to lead original research projects. Graduates will be prepared for academic teaching and research positions, and government and industry research.

**Student Learning Outcomes, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans**

**O 1: Original research**  
Graduates will develop expertise in a subdiscipline of geophysics, and be able to conduct independent original research in that area.

**Associations:**

General Education or Core Curriculum:

2 Demonstrate critical analysis skills

**Related Measures:**

**M 1: Publication of research results**  
The graduate committee will collect data on student publishing.

Source of Evidence: Existing data

**Achievement Target:**  
90% of graduating students will have at least one manuscript in publication or submitted for publication at the time of their defense.  
50% of graduating students will have at least two manuscripts in publication or submitted for publication at the time of their defense.

**Findings (2008-2009) - Achievement Target: Partially Met**  
50% of the graduating PhD students had 1 manuscript submitted at the time of their defense; 50% had 2 manuscripts submitted.

**M 2: Visibility at professional meetings**  
The graduate committee will collect data on student presentations at national conferences and workshops.

Source of Evidence: Existing data

**Achievement Target:**  
75% of students will participate in a research presentation at a professional meeting, on average, at least once per year.

**Findings (2008-2009) - Achievement Target: Partially Met**  
The 2008-09 PhD graduates averaged 2.0 presentations at professional meetings during their tenure.

**O 2: Broad background**  
Graduates will have a basic knowledge of fundamental geophysical principles, and supporting science

**Associations:**

General Education or Core Curriculum:

1 Master the depth of knowledge required of a discipline
Related Measures:

M 4: Demonstrated breadth
The graduate committee will collect data on qualifying exams.
Source of Evidence: Existing data

Achievement Target:
75% of students taking their preliminary exam will be deemed by their committee to have no significant deficiencies in background that require further coursework or remedial study.

Findings (2008-2009) - Achievement Target: Not Met
Data are not available. Tracking of Prelims and the results will have be done at the department level on a case-by-case basis. This was not done during 2008-09.

Related Action Plans:
Monitor prelim results
Recommendations for additional coursework made by prelim committees are not usually part of the official report. They will have to be monitored at the department level.

For more information, see the Action Plan Details section of this report.

O 3: Effective Communication
Graduates will be able to communicate their findings in written reports and in oral presentations

Associations:
General Education or Core Curriculum:
3 Communicate effectively in writing and speaking

Related Measures:

M 1: Publication of research results
The graduate committee will collect data on student publishing.
Source of Evidence: Existing data

Achievement Target:
90% of graduating students will have at least one manuscript in publication or submitted for publication at the time of their defense.
50% of graduating students will have at least two manuscripts in publication or submitted for publication at the time of their defense.

Findings (2008-2009) - Achievement Target: Partially Met
50% of the graduating PhD students had 1 manuscript submitted at the time of their defense; 50% had 2 manuscripts submitted.

Related Action Plans:
Add a writing-intensive graduate course
The department has added a writing-intensive graduate course, in hopes of encouraging graduate students to begin preparing
publications earlier during their tenure. The first such course, which covered the mechanics of writing abstracts, manuscripts, reports, and grants, was offered during Spring 2009, and may be offered each semester in the future. For more information, see the Action Plan Details section of this report.

M 2: Visibility at professional meetings
The graduate committee will collect data on student presentations at national conferences and workshops.

Source of Evidence: Existing data

Achievement Target:
75% of students will participate in a research presentation at a professional meeting, on average, at least once per year.

Findings (2008-2009) - Achievement Target: Partially Met
The 2008-09 PhD graduates averaged 2.0 presentations at professional meetings during their tenure.

Other Outcomes/Objectives, with Any Associations and Related Measures, Achievement Targets, Findings, and Action Plans

O 4: Internship
The Department will encourage graduate students to take internships with energy companies, environmental firms, or government laboratories

Associations:

Institutional Priorities:

4 Expand off-campus opportunities, such as internships, study-abroad, and service-learning.

Related Measures:

M 3: Student Exit and Entrance surveys
The Department will conduct surveys of incoming students and finishing students (prior to their dissertation defense), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

Achievement Target:
35% of PhD students will take a summer internship in an energy company, environmental firm, or government laboratory

Findings (2008-2009) - Achievement Target: Met
The interview forms for 2008-09 did not distinguish between Geol and Geop students nor between MS and PhD. Of all students graduating, 75% held a summer internship during their tenure.

O 5: Job Placement
Graduates will be competitive for highly-sought research and leadership positions in industry, and faculty positions in academia.
### Strategic Plans:

**Texas A&M University**

- 2 Strengthen our graduate programs.

### Related Measures:

#### M 3: Student Exit and Entrance surveys

The Department will conduct surveys of incoming students and finishing students (prior to their dissertation defense), to determine their expectations, goals, achievements, career plans and satisfaction with the program.

Source of Evidence: Student course evaluations on learning gains made

**Achievement Target:**
80% of students will complete both surveys

**Findings (2008-2009) - Achievement Target: Partially Met**
The survey forms for 2008-09 did not distinguish between Geol MS, Geol PhD, Geop MS, or Geop PhD. Of the graduating students 4/12 = 33% completed the survey.

#### M 5: Graduate tracking

The Department will collect data on students career path.

Source of Evidence: Existing data

**Achievement Target:**
90% of graduates will attain jobs at an academic department or in a government or industry research lab.

**Findings (2008-2009) - Achievement Target: Met**
The survey forms for 2008-09 did not distinguish between Geol MS, Geol PhD, Geop MS, or Geop PhD; 100% of those completing the survey obtained positions as professional geologists/geophysicists.

### Details for Action Plans Established This Cycle

#### Add a writing-intensive graduate course

The department has added a writing-intensive graduate course, in hopes of encouraging graduate students to begin preparing publications earlier during their tenure. The first such course, which covered the mechanics of writing abstracts, manuscripts, reports, and grants, was offered during Spring 2009, and may be offered each semester in the future.

- **Priority:** High
- **Target Date:** 01/2009
- Course was first taught during Spring 2009

#### Monitor prelim results

Recommendations for additional coursework made by prelim committees are not usually part of the official report. They will have to be monitored at the department level.

- **Priority:** High
- **Target Date:** 09/2009
We will begin the monitoring during Fall 2009

**Analysis Answers**

**For Student Learning Outcomes:** Based on the assessment findings, what changes will be made to enhance student learning?

Students will be encouraged to enroll in the new graduate-level W course.

**For Program Outcomes:** What changes will be made to the program as a result of your assessment of other program outcomes?

Not Applicable

**Assessment Process:** Reflecting on the program's assessment process, what changes do you intend to make to the assessment plan?

1) We will contact students individually during their final semester and encourage them to provide information needed in the assessment process.

2) We will closely monitor the requests to schedule preliminary exams, and request information about the committee’s recommendations.

**Annual Reports**

**Program Contributions**

It is notable that all of our graduates at the MS and PhD levels during this cycle obtained permanent employment as professional geoscientists.
Appendix D. Research Publications

D.1. Papers in Refereed Journals
2009


Bahlburg, H., Weiss, R., Wünneumann K. (in review) Low energy deposition in the Chicxulub crater during the impact to post-impact transition, in review at *EPSL*.


in Tom Mays Canyon, Franklin Mountains, TX and the San Juan Mountains, CO USA, Zeitschrift
für Geomorphologie.

Dor, O., J.S. Chester, Y. Ben-Zion, J. Brune, T.K. Rockwell (2009) Characterization of Damage in
Sandstones Along the Mojave Section of the San Andreas Fault: Implications for the Shallow
Extent of Damage Generation, Pure Appl. Geophys., 166, 1747-1773, doi:10.1007/s00024-009-
0516-z.

Dou, Q., Y. Sun, and C. Sullivan (in revision) Paleokarst system development in the San Andres
formation, Permian Basin, revealed by seismic characterization, submitted for publication in
Geomarine Letters.

Duan, B. (in review) Role of initial stress rotations in rupture dynamics and ground motionL A case study

Duggen, S., K. Hoernle, F. Hauff, and J. Geldmacher J. (in review) Geochemistry of basalts across the
lava-sheeted dike transition zone in ocean crust of Hole 1256D (Cocos Plate, Eastern Pacific)
Constraints on temporal changes of mantle processes and subsequent style and timing of alteration.
Submitted to Geochemistry, Geophysics, Geosystems

coreholes, Chesapeake Bay impact structure: Post-impact sediments, 444 to 0 m depth. In: Gohn,
G.S., Koeberl, C., Miller, K.G., and Reimold, W.U., (Eds.), The ICDP-USGS Deep Drilling Project
in the Chesapeake Bay Impact Structure: Results from the Eyreville Core Holes: Geological

Everett, M.E. (2009) Transient electromagnetic response of a loop source over a rough geological

Fall, L.M., and Olszewski, T.D. (in review) Basinal disruptions influence taxonomic composition of
brachiopod paleocommunities in the Middle Permian Bell Canyon Formation (Delaware Basin,
West Texas), submitted for publication in Palaios.

Fu, Y., and H. Zhan (2009) On the origin of oil-field water in the Biyang Depression of China,
Environmental Geology, 58(6), 1191-1196.

Gao, G., H. Zhan, S. Feng, B. Fu, and G Huang (in review) A mobile-immobile model for reactive solute

simulating anomalous solute transport in a large heterogeneous soil column, J. Hydrol., 377, 391-
404.

large heterogeneous soil column with mobile-immobile model, ASCE J. Hydrologic Engineering,
14(9), 966-974.

Geldmacher, J., B. Hanan, K., Hoernle, and J. Blichert-Toft (in review) Hafnium isotopic variations in
East Atlantic intraplate volcanism, submitted for publication in Chemical Geology.

Giardino, J.R., Vitk, J.D., Gillespie, B.M. (in review) Conceptual Development of an Introductory
Geology Course for Non-Majors. Journal of Geoscience Education.


He, W., Sparks, D., and Hajash, A. (in review) Reactive transport at stressed grain contacts and rate-controlling processes for pressure solution, submitted for publication to *J. Geophys. Res.*


Li, J., H. Zhan, and G. Huang (in review) On the applicability of linearization method of vapor flow in porous media, submitted for publication in *Vadose Zone J.*


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2008


2007


Nance, R. D., B. V. Miller, J. D. Keppie, J. B. Murphy, and J. Dostal (2006b) Acatlan Complex, southern Mexico: Record spanning the assembly and breakup of Pangea, Geology (Boulder), 34(10), 857-860.


2005


**2003**


2002


D.2. Electronic and Non-Refereed Articles


Digital Gallery for Paleochemical Specimens and Thin-sections (DiGPaST) (includes photomicrographs of brachiopod shell thin-sections in plane light and cathodoluminescence) http://geoweb1.tamu.edu/faculty/grossman/DiGPaST/index.html


2008


Ilk, D., A.D. Perego, J.A. Rushing, and T.A. Blasingame (2008) Integrating multiple production analysis techniques to assess tight gas sand reserves: defining a new paradigm for industry best practices,


2007


2006


2005


Craig, D.P., and T.A. Blasingame (2005) A new refracture-candidate diagnostic test determines reservoir properties and identifies existing conductive or damaged fractures, SPE 97972, Annual SPE Technical Conference and Exhibition, Dallas, TX, 09-12 October.


Kompani-Zare, M., N. Samani, and H. Zhan (2005) Seepage rate from dry section of Qanat, *2nd International Conference on Qanat*, Kerman City, Iran, May.


2004


2003


2002


D.3. Books & Book Chapters


2008


2007


2006


2005


2004


2003


2002


D.4. Patents
2009


2004

D.5. Abstracts and Presentations


Aze, T., Pearson, P.N., Wade, B.S., Bown, P.R., Kroon, D. and the GLOW Project Team (2009) A biostratigraphic report from the GLOW site survey cruise of the southwest Indian Ocean. EuroMARC Scientific Committee meeting, September.


Sills, D., J.S. Chester, and F.M. Chester (2009) Fault-Related Deformation of Fine Grained Clastics at the San Andreas Fault Observatory at Depth (SAFOD) Inferred from CT Imaging, AAPG Abstracts with Programs, p. 41.


stratigraphic interpretations of Antarctic glaciation and ocean de-acidification, *Antarctic Climate Evolution (ACE) Symposium*, Granada, Spain, 7-11 September.


2008


Duggen, S., K. Hoernle, F. Hauff, J. Geldmacher (2008) Trace element and isotopic geochemistry of ~15 Ma oceanic crust formed at a superfast spreading ridge (Exp. 309/312, IODP Site 1256D, Eastern Pacific): Constraints on sub-ridge processes, the style and timing of alteration, and the origin of ocean island basalts, IODP-ICDP Kolloquium, March 2008, Hannover/Germany, p. 43.


Soule, D. and M.E. Everett (2007) High resolution seismic imaging at the Odessa (TX) meteorite impact site: the ground-impact geohazard and integration with magnetic gradiometry and time-domain electromagnetics, EOS Trans. AGU, 88 (23), NS31A-03.


Appendix E. Research Funding

E.1. Research Grants and Contracts
2009

Appache (TAMU-500182), TAMU Reservoir Geophysics Program Scholarship, (September 1, 2009 – December 31, 2010) Co-PIs: Sun, Y.F. $60,000, funding one M.S. student.


Geoinfo LLC and China Petroleum & Chemical Corp. (Sinopec), TAMU Reservoir Geophysics Program (TAMU-500182), Integrated Geological and Geophysical Reservoir Characterization and Reservoir Quality Prediction (November 1, 2009 – October 31, 2011) Co-PIs: Sun, Y.F., $450,000, funding four Ph.D. students.

ICDP, Peering into the Cradle of Life: Scientific Drilling in the Barberton Greenstone Belt, South Africa, $400,000, Tice, M.M. PIs: Nicholas Arndt (Université J. Fourier, France), Alan Wilson (University of Witswatersrand, South Africa), Axel Hofmann (University of Kwazulu-Natal, South Africa), Gary Byerly (Louisiana State University). (participating as drilling team leader)

National Science Foundation of China-40872166, Theoretical and experimental study of solute non-Fickian transport in fractured media (2009-2011) PIs: Qian, J., and H. Zhan, RMB 390,000, funded one graduate student.


NSF Cooperative Agreement EAR-0529922 and USGS Cooperative Agreement 07HQAG0008 (RF-499881-01001), Characterization of Pulverized Granitoids in the Little Rock Core Along the San Andreas Fault, Southern California Earthquake Center (SCEC) (02/09-1/2012) Chester J.S. Co-PIs: T. Rockwell (San Diego State University), Y. Ben-Zion (University of Southern California), $40,000 total, $7,000 (TAMU), partial funding for two graduate students, Neta Wechsler (USC) and Emily Allen (UCSD)

NSF Grant EAR-0911586 (RF-425591), Experimental and Natural Deformation of Magnesian Carbonates (June 23, 2009 - June 22, 2012) Co-PIs: Newman, J., C. Holyoke III, and A.K. Kronenberg, $399,744, funding one post-doctoral fellow, one graduate student, and one undergraduate student.


NSF-EAR-0956094, CAREER: Sediments and sediment transport due to tsunamis, pending, $588,227. Weiss, R. 2 students


NSF-OCE-0851056, $^{230}$Th dynamics in the Eastern Equatorial Pacific Ocean: testing the $^{230}$Th-normalization method to estimate sediment fluxes, July 1, 2009 - June 30, 2012, $401,841, Marcantonio, F. (co-PI Dr. M. Lyle—TAMU Oceanography; support for PhD graduate student Ajay Singh, undergraduate student Alyssa Franklin, and 8 graduate/undergraduate students to go to sea for 1 month to work on project).


RPSEA, Coupled Flow-Geo-Mechanical-Geophysical-Geochemical (F3G) Analysis of Tight Gas Production (2009-2011) Co-PIs Dr. T.A. Blasingame, Dr. G. Moridis (Lawrence Berkeley) $2,900,000.

SCEC 2009, A collaborative project: 3D rupture dynamics, validation of the numerical simulation method (Feb. 1, 2009 - Jan. 31, 2010), Duan, B. $14,000.

Texas Department of Transportation Unknown Foundation Determination for Scour (2009) PIs: J.L. Briaud (TAMU CVEN), S. Hurlebaus (TAMU CVEN), Z. Medina-Cetina (TAMU CVEN), M.E.Everett. $293,000. Student supported: Rungroj Arjwech.


Texas Water Development Board, Office of Sponsored Projects VPR Office, Formation and Development of Meanders on the Brazos River, Texas (Rates of Channel Migration in Relation to Discharge), (June 2009-August 2010)., Co-PI Dr. J.R. Giardino, $40,000, funding one graduate student.


2008


DOE/SCEC2008, Physical limits on ground motion at Yucca Mountain and dynamic code validation (Sept. 1., 2008-Jun. 30, 2010), Duan, B. $55,000, funding partially one Postdoctoral researcher.
DOE/SCEC2008, Physical limits on ground motion from ruptures on non-planar faults with off-fault damage (Feb. 1, 2008-Jun. 30, 2010), Duan, B. $28,000.

ExxonMobil Study Sponsorship Agreement #E-2008-ETC-009, X-Ray Computed Tomography (CT) Study of Phase 3 Spot Core from the San Andreas Fault Observatory at Depth (SAFOD) (01/08-12/08), Chester, J.S. $25,000, partial support for two graduate students, Clayton Coble and David Sills.

Incorporated Research Institutions for Seismology, Technology assistance with implementation and operation of Transportable Array element of USArray and Earthscope (March 1, 2008 – Sept. 30, 2008), $31,000 to TAMU, P.I.: D. Sparks; summer funding for two graduate students.


NSF Cooperative Agreement EAR-0529922 and USGS Cooperative Agreement 07HQAG0008, Workshop on The Structure and Formation of Fault Zones, and Their Role in Earthquake Mechanics, Southern California Earthquake Center (SCEC) (6/2008) Organizing Committee: C.G. Sammis (University of Southern California), J. S. Chester, J. R. Rice (Harvard University), T. Tullis (Brown University), Y. Ben-Zion (University of Southern California), $10,000.

NSF Cooperative Agreement EAR-0529922 and USGS Cooperative Agreement 07HQAG0008 (RF-499881-01001), Frictional Strength and Microstructures of SAFOD Gouge Sheared at Coseismic and Aseismic Creep Rates, Southern California Earthquake Center (SCEC), (02/08-1/2012) Chester, J.S. Co-PI: F.M. Chester, $19,999, partial funding for two graduate students, Hiroko Kitajima, and Clayton Coble.

NSF Cooperative Agreement EAR-0529922 and USGS Cooperative Agreement 07HQAG0008 (RF-499881-01001), Depth Characterization of Pulverized Granite Along the San Andreas Fault, Southern California Earthquake Center (SCEC) (02/08-1/2009) Chester, J.S. Co-PIs: T. Rockwell (San Diego State University), Y. Ben-Zion (University of Southern California), $30,000, $5,194 (TAMU), partial support for two graduate students, Neta Wechsler (USC) and Emily Allen (UCSD).

NSF Grant DUE-0717768, The CIRTL Network - Shaping, Connecting, and Supporting the Future National STEM Faculty (2008-2011) P.I: Mathieu, B. (University of Wisconsin), Co-PIs: Herbert, B.E. (Texas A&M); Ann Austin (Michigan State), Patricia Rankin (U. of Colorado), Rique Campa (Michigan State) $4.1 million ($472k, TAMU share). Funds 15 graduate students.

NSF Grant OCE-0550743 (RF491261-02001) Geophysical and Geochemical Site Survey of Ninetyeast Ridge – Testing the Hotspot Hypothesis Supplement (June 1, 2008 – August 31, 2009, P. I. William Sager, $50,000, funding two graduate students.

NSF-EAR-0809571, Collaborative Research: Integrating observations of low-velocity fault zones with models of spontaneous dynamic earthquake ruptures (Sept. 1, 2008-Aug. 31, 2009, extended to
Aug. 31, 2010) Duan, B. Co-PI: Y.-G. Li (USC), $75,000 (TAMU budget), funding one graduate student.


Texas Higher Education Coordinating Board, Advanced Research Program 010366-0087-2007, Is the water table a material free surface? (2008-2010), Co-P.I.s: H. Zhan, D. Sparks. $120,000, Two years of funding for two graduate students.


Texland Resources (2008) Genetic Pore Typing as a Means of Characterizing Reservoir Flow Units: San Andres, Sunflower Field, Terry County, Texas, $10,000, Ahr, W.M.

USGS-NEHRP-08HGR0048, Spontaneous dynamic rupture propagation with off-fault plastic yielding, tensile crack generation, and damage rheology and the effects on ground motion (Feb. 1, 2008-Jan. 31, 2009, extended to Jan. 31, 2010), Duan, B. $68,545, funding partially one Postdoctoral researcher.

2007

ACS-PRF Grant 46096-G8, Refining Sequence Stratigraphic Interpretations Using Benthic Fossil Communities from the Permian Basin of West Texas. (January 1, 2007 - August 31, 2009) Olszewski, T.D. $40,000, funding one graduate student.

ADNOC (Abu Dhabi National Oil Company), (RF-499531, RF-424231), Multi-Component Seismic Analysis for Reservoir Description Research Project, (July 1, 2007 – June 30, 2011) Co-PIs: Sun, Y.F., $394,000, funding one graduate student with a new RF # to be assigned in 2010 for Phase III.


Conoco/Phillips, New 3D structural interpretation of the Taiwan Fold and Thrust Belt, Wiltschko, D.V., $31,550, funding for a graduate student, 10/2007-11/2008,


Industrial Consortium, (TAMU-500182), TAMU Reservoir Geophysics Program, (September 1, 2007 to present) Co-PIs: Sun, Y.F. $39,000.

NSF Cooperative Agreement EAR-0106924 and USGS Cooperative Agreement 02HQAG0008 (RF-499881-01001), Continuation - Investigation of Weakening Mechanisms in High-speed Experimental and Natural Slip-surfaces, Southern California Earthquake Center (SCEC) (10/07-
1/2012, came in late 4/08) Chester, J.S. $19,999, partial funding for one graduate student, Hiroko Kitajima.

NSF Grant EAR-0643339 (RF- 496421), Collaborative Research: Influence of Structure, Composition and Fluid-rock Chemistry on Mode of Slip in the San Andreas Fault Zone at SAFOD (6/07-5/09, extended to 5/2010). Chester, J.S. Co-PIs: F.M. Chester, J.P. Evans (Utah State University), D. Kirschner (Saint Louis University), $399,021 total, $201,398 (TAMU budget), partial for one undergraduate student, Andrew Becker, and three graduate students, Bretani Heron, David Sills, and Clayton Coble.


NSF Grant EAR-0643309, Carboniferous Chemostratigraphy: Do Epicontinental Seas Reflect Global Ocean Conditions? (October 1, 2007- September 31, 2010) PI: Dr. D. Thomas; Co-PIs: Dr. E. Grossman, Dr. B. Miller, Olszewski, T.D., Dr. T. Yancey, $290,801, funding one graduate student and one undergraduate student.

NSF-Hydrological Sciences-Flow-Induced Redox Geochemistry within Fractured/Macroporous and Layered Vadose zone 05/07 $480,000, McGuire, J.T. Co-PI with Binayak Mohanty.

2006


Apache Corporation, Klinkenberg-Correction for Low Permeability Sandstones (2006) PI Dr. T.A. Blasingame, $10,000.


ExxonMobil, Reservoir Characterization of the Cerro-Negro Field (Venezuela) Using Production and Well Test Data Analysis/Interpretation (2006-2007) PI Dr. T.A. Blasingame, $101,000.

Federal Highway Administration. Aggregate-asphalt interactions: Role of mineral surface chemistry, organic functional groups and competition with water (2006-2011) Flexible Pavements Consortium (Western Research Institute (University of Wyoming), the Texas Transportation Institute (TAMU), the University of Wisconsin-Madison, University of Nevada-Reno and Advanced Asphalt Technologies, LLC at Sterling, Virginia). $57 million (Herbert share $300,000). Funds 2 graduate students.

NSF Cooperative Agreement EAR-0106924 and USGS Cooperative Agreement 02HQAG0008, DOSECC, Workshop on Origin and Depth Extent of Pulverized Rock Along Active Continental Faults in Southern California: Possible Insights to be Gained From Shallow Boreholes, Southern California Earthquake Center (SCEC) (9/06) Chester, J.S. Co-PIs: J. P. Evans (Utah State University), T. Rockwell (San Diego State University), Y. Ben-Zion (University of Southern California), $5,000 (DOSECC) $5,950 (SCEC).

NSF Cooperative Agreement EAR-0106924 and USGS Cooperative Agreement 02HQAG0008 (RF-499881-00001), Investigation of Weakening Mechanisms in High-speed Experimental and Natural Slip-surfaces, Southern California Earthquake Center (SCEC) (2/06-1/07) Chester, J.S.
Collaboration with T. Shimamoto (Kyoto University) and F. M. Chester, $20,000, partial funding for one graduate student, Hiroko Kitajima.


NSF OCE, *Did Deep Waters Form at High Latitudes During the Middle to Late Cretaceous Greenhouse?* (September 2006 – August 2009) PI: Thomas, D.J., $155,585.


Petroleum Research Fund Proposal PRF-45018-AC8 (RF490291-00001). *Multichannel Seismic Analysis of Gas Hydrate and Related Geological Structure in the NW Gulf of Mexico* (September 1, 2006 – August 31, 2008), P. I., William Sager, $80,000, one graduate student supported.

Qatar Petroleum Research Program Associates, *Identification and assessment of carbonate facies, pore systems, and mineralogical trends as candidates for acid stimulation and reservoir enhancement* (Fall 2006 - Summer 2009), Co-PIs: Ahr, W.M., and J. Jensen (Univ Calgary) $140,000


United States Department of Agriculture (USDA), *FAIM Program,* USDA (September 2006-September 2007) Co-PI Dr. Giardino, $480,976.

2005

Anderson Energy Partners, *Identification and quality ranking of reservoir flow units, Jurassic Smackover Formation at Grayson field, Arkansas employing comparative study of image analysis, measured poroperm values, and NMR measurements* (September 1 2005 – August 31 2006), PI: Ahr, W.M., $22,785.

Center for Environmental and Rural Health-NIH. *Correlating Biogeochemical Processes at Mixing Interfaces within a Contaminated Aquifer-Wetland System,* 07/03, McGuire, J.T. $25,000.


DOE-DE-FC26-02NT15342, Development of advanced seismic evaluation processes for hydrocarbon fluid saturation in deep water reservoirs, 9/1/2002-8/31/2005, $750,000 ($265,789 to Texas A&M), Gibson, R.L. (PI: Michael Batzle, Colorado School of Mines, co-PI: De-hua Han, Univ. of Houston, Paradigm Geophysical Inc. was a partner also). Funding about 3 graduate students.


Lone Star Infrastructure. Amelioration of ettringite formation in lime-amended soils using cyclodextrin amendments (2004-2005). Co-PIs: D. Little (Civil Engineering) and B. Herbert (Geology). $50,000. Funds 1 graduate student and three undergraduate students.


National Park Services (NPS), Assessment of Water Resources and Watershed Conditions in and Adjacent to Cape Krusenstern National Monument and Bering Land Bridge National Preserve, Alaska (May 2005- August 2006) Co-PI Dr. R. Kaiser and Dr. Giardino, $89,659.

National Science Foundation of China-50428907, Non-Darcian flow and transport in porous and fractured media (2005-2007) PIs: Zhan, H., and G. Huang, RMB 400,000, funded one graduate student.

NSF (EAR-0126311). Collaborative Research: Constraining Tertiary temperatures, salinities, and ocean chemistry: An isotopic and trace-metal study of serially-sampled mollusks. E. Grossman, Y. Rosenthal (Rutgers U.), and C. Lear (Cardiff U.), 1/1/02-12/31/05, $79,005 (TAMU; Total = $132,943). Also David Hicks (UT Brownsville).

NSF (EAR-03152216). CHRONOS Network for Earth System History: Development of Integrated Databases, Portals and Toolkits, Subcontract through Iowa State University, E. Grossman, 8/1/03-7/31/07, $50,194 (C. Cervato, PI with 14 co-PIs; total = $1.7M) (Also received $35,000 to organize CHRONOS's Geochemical Cycles Workshop).

NSF (EAR-0321278). MRI: Acquisition of Stable Isotope Facilities for Geologic Research at Texas A&M University E. Grossman, 8/15/03 - 7/31/05, $252,907.

NSF (EAR-0524285). The CHRONOS System: Geoinformatics for Deep-time Earth Processes, Subcontract through Iowa State University, E. Grossman, 8/1/05-7/31/07, $35,000 (C. Cervato, PI with 7 subcontractors; total = $1.1M).
NSF Cooperative Agreement EAR-0106924 and USGS Cooperative Agreement 02HQAG0008, FARM/ESP/Earthquake Geology Field-based Workshop for the 2005 SCEC Annual Meeting: Recent advances in fault zone studies and their impact on earthquake source processes, Southern California Earthquake Center (SCEC) (9/05) Chester, J.S. Co-PIs: F.M. Chester, J. P. Evans (Utah State University), $7,000 total.

NSF Cooperative Agreement EAR-0106924 and USGS Cooperative Agreement 02HQAG0008 (RF-499881-00001), Characterization of Microstructures Relevant to Earthquake Mechanics in Natural and Experimental Slip Surfaces, Southern California Earthquake Center (SCEC) (2/05-1/06) Chester, J.S. Collaboration with T. Shimamoto (Kyoto University) and F.M. Chester, $23,000, partial support for one graduate student, Hiroko Kitajima.

NSF Cooperative Agreement EAR-0106924 and USGS Cooperative Agreement 02HQAG0008 (RF-499881-00001), Quantification of the Structural and Chemical Properties of Slip Surfaces Taken from Exhumed Faults of the San Andreas System, Southern California Earthquake Center (SCEC) (2/04-1/05), Chester, J.S. $20,000.

NSF Grant DEB-0129208 and DEB-0547244 Environmental and Temporal Patterns in Land Plant Diversity through Geologic Time (Jan. 15, 2002 - Dec. 31, 2006) P.I.'s Hallie Sims (U. Iowa), Pat Gensel (U. North Carolina), Scott Wing (Smithsonian Institute), $355,362 (Smithsonian and U. of Iowa). This grant funded the Paleobotany Working Group of the Paleobiology Database. In addition to the P.I.'s the working group includes: W. A. Stein (SUNY Binghamton), Allister Rees (U. Arizona), Bruce Tiffney (U.C. Santa Barbara), Peter Wilf (Penn State), Rick Lupia (U. Oklahoma), W. A. DiMichele (Smithsonian Institute), R. A. Gastaldo (Colby College). Raymond, A. In the 2005-2006 period, I received $3000 to travel to two workshops.

NSF Grant EAR-0409567, Collaborative Research: Determining mantle rheology from field and microstructural observations of naturally-deformed peridotites (July 1, 2004 – June 30, 2009) P.I. J. Newman, collaborative research with B. Tikoff, University of Wisconsin-Madison and T. Little, Victoria University of Wellington, New Zealand, $89,000 (Texas A&M), funding one research scientist and one undergraduate student.

NSF Grant EAR-0310284 (RF-459721) Experimental and Petrofabric Study of Hybrid Fractures and the Transition from Joints to Faults (6/03-5/06) PI: F. M. Chester, Co-PI: J.S. Chester, $299,546, partial funding for three graduate students, Erika Rodriguez, Jen Bobich, Anne Heron.


NSF Grant EAR-0345618 Mechanisms and rates of Preservation of Biogenic Remains in Continental Shelf and Slope Environments (Oct. 1, 2004 - Sept. 30, 2009) P.I. Karla Parsons-Hubbard (Oberlin College), Co-P.I.'s E. A. N. Powell (Rutgers University), Sally Walker (U. Georgia), Carleton Brett (U. Cincinnati), A. Raymond (TAMU), G. Staff (Austin Community College), R. Callender (U. Virginia), $503,723 (to Oberlin), this money funded 2 research cruises - at a cost of $65,000 per co-P.I.

NSF Grant EAR-0454525 (RF- 467711), **Collaborative Research: Structural-Petrologic Characterization of the San Andreas Fault Zone in the SAFOD Drill Holes** (6/05-5/08) Chester, J.S. Co-PIs: F.M. Chester, J. P. Evans (Utah State University), D. Kirschner (Saint Louis University), $244,975 total, $119,982 (TAMU budget), partial funding for two undergraduate students, Andrew Becker and T.J. Waller, and three graduate students, Rafael Almeida, Tersa Sabato Ceraldi, and Hiroko Kitajima.

NSF Grant EAR-0510892 (RF- 468571), **Geologic Constraints on Fracture Energy of the San Andreas Fault** (6/05-5/2009, extended to 5/2010) National Science Foundation, Chester, J.S. Co-PI: F. M. Chester, $303,094, partial funding for three graduate students, Hiroko Kitajima, Teresa Sabato Ceraldi, and Ory Dor (University of Southern California).

NSF Grant OCE-0221250, **Seismic Petrology of the Lower Oceanic Crust: A Proposal to Investigate the Relationships between Seismic Velocity, Modal Mineralogy and Water Content in Diabase and Gabbro Samples from ODP Holes 504B, 735B, 894G and 923A.** (May 1, 2003 – April 30, 2006) P.I. R.L. Carlson, Co-P.I.’s, D.J. Miller, J. Newman, Texas A&M University, collaborative research with J.M. Brown, University of Washington, $262,836 (Texas A&M), funding one research scientist, one graduate student, and 1 undergraduate student.

NSF Grant OPP-0447440, **Collaborative Research: A Geophysical Transect Across the Arctic Ocean:Multi Channel Seismic Reflection & Seismic Refraction Data Acquisition on the USCG Icebreaker Healy, Summer 05** (September 2004-August 2007), PI: Hopper, J.R. $99,625.

NSF Grant TPC-0353377, **The Professional Learning Community Model for Alternative Pathways in Teaching Science and Mathematics** (2004-2009) PI: Herbert, B.E., Co-PIs: Cathy Loving (College of Education), Maureen Loiaicano and Linda Crow (Lonestar College), and Guy Sconzo (Humble ISD) $3.1 million, funds 10 graduate students.

NSF Grant, EAR-99009638, **The Thermo-kinematic evolution of the Taiwan mountain belt:** $139,475, Wiltschko, D.V. 1/00-12/06.


NSF-EAR 0439665; **Collaborative Research: A Record of the Timing, Nature and Geometry of the Rheic Ocean in the Appalachian Carolina and Avalon Zones,** 01/01/2005 Miller, Brent, Texas A&M Research Foundation $134,104.00.


NSF-OCE-0137157, **Collaborative Project: Seismic Petrology of the lower oceanic crust,** 2002-2006, $262,836, Carlson, R. Co-PIs Dr. J. Newman, Dr. D. Miller.


TAMU-CONACYT (Mexico) Collaborative Research, Sea water upconing under pumping horizontal wells in coastal aquifers (2004-2005) PIs Zhan, H., and R. Vázquez-González, $24,000, funded one graduate student.


Texas Department of Transportation Simplified Method for Estimating Scour, 1 September 2005 — 31 August 2007, jointly with Civil Engineering and Texas Transportation Institute, $222,575.00, Mathewson, C. supported 1 graduate student.


E.2. Unfunded Research Projects
2009

Carlson, R. (2009) *Modeling the affect of cracks on seismic velocities in the upper oceanic crust*  
Unfunded Research.


Gibson, R. (2009) *Sensor network design for seismic monitoring* Unfunded Research, Collaborators: N. Gautam (Dept. Industrial and Systems Engineering) and R. Gibson, including one graduate student in Industrial Engineering.


Tice, M.M. (2009) *Trace Metal Cycling in the 3.26 Ga Fig Tree Group, Barberton Greenstone Belt, South Africa* Unfunded Research, Collaborators: C.-T. A. Lee (Rice) and D.R. Lowe (Stanford).

2008

Collaborators: Wu, X. (Computer Science at TAMU).

Unfunded ResearchCollaborators: B. Dickson (TAMU ANTH).


### 2007


Wiltschko, D.V. (2007-2009) Integrating kinematic and thermochronologic data to date fold and thrust belts Unfunded Research, Collaborators, Shay Chapman, Jennifer Piper, Harold Johnson


2006


2005


Grossman, E. (2005) Constraining Late Paleozoic climate, CO2 levels, and ice sheet volumes: Integration of oxygen isotopes with climate and ice sheet models, Unfunded Research, and W. Hyde (University of Toronto), David Pollard (PSU), Tom Crowley (Edinburgh University). Continuation of project previously funded by NSF.


Yancey, T.E. (2005-2009) *Structure, ontogeny and function of the Middle Eocene Belosaepia ungula (Cephalopoda: Coleoida) from Texas*: Unfunded Research, Collaborators: C. Garvie, Natural History Museum, Austin, TX and M. Wicksten -- Results in press

Appendix F. Awards and Honors
2009  AFS College of Geosciences Teaching Award
Raymond, A.
College of Geosciences, Texas A&M University

2009  Award for Research in Rock Mechanics
Karner, S.L., A.K. Kronenberg, J.S.
Chester, F.M. Chester, and A. Hajash,
American Rock Mechanics Association
42nd US Rock Mechanics Symposium,
San Francisco CA

2009  David B. Harris Chair in Geology
Chester, F.M.
College of Geosciences, Texas A&M University

2009  Dean's Distinguished Achievement Award
in Faculty Teaching
Zhan, H.
College of Geosciences, Texas A&M University

2009  EOG Teaching Professorship in Geosciences
Herbert, B.E.
College of Geosciences, Texas A&M University

2009  Francesco Paolo diGangi/Heap Professor in Theoretical Geophysics
Gibson, R.
College of Geosciences, Texas A&M University

2009  Howard Karren Professor in Geology and Geophysics
Everett, M.E.
College of Geosciences, Texas A&M University

2009  Industry Pioneer Award
Rabinowitz, P.D.
Offshore Energy Center, Houston TX

2009  Keith Runcorn Travel Grant
Kronenberg, A.K.
European Geosciences Union

2009  Michel T. Halbouty Chair in Geology
Grossman, E.L.
College of Geosciences, Texas A&M University

2009  Named Applications Researcher in Texas A&M Institute
for Applied Mathematics and Computational Research
Gibson, R.

2009  NSF CAREER Award
Wade, B.S.
NSF

2009  Ray C. Fish Professor in Geology
Zhan, H.
College of Geosciences, Texas A&M University

2009  Schuchert Award Winner
Olszewski, T.D.
Paleontological Society

2010  Grover E. Murray Memorial Distinguished Educator Award
Ahr, W.M.
American Association of Petroleum Geologists
Nominated in 2009, to be Awarded at April AAPG Meeting
<table>
<thead>
<tr>
<th>Year</th>
<th>Award</th>
<th>Recipient</th>
<th>Organization/Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Distinguished Service Award,</td>
<td>Ayers, W.B.</td>
<td>American Assoc Petroleum Geologists, Energy Minerals Division</td>
</tr>
<tr>
<td></td>
<td>2008-2009 Distinguished Lecturer</td>
<td>Thomas, D.J.</td>
<td>Consortium for Ocean Leadership</td>
</tr>
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<td></td>
<td>2008 Montague Center for Teaching Excellence Award,</td>
<td>Thomas, D.J.</td>
<td>Texas A&amp;M University</td>
</tr>
<tr>
<td></td>
<td>2008 Karl and Ruth Terzaghi Outstanding Mentor Award</td>
<td>Mathewson, C.</td>
<td>Association of Environmental and Engineering Geologists</td>
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<td></td>
<td></td>
<td></td>
<td>Annual Meeting, 18 September.</td>
</tr>
<tr>
<td></td>
<td>2007 Pete Henley Mentor Award,</td>
<td>Mathewson, C.</td>
<td>Texas Section, Association of Environmental and Engineering Geologists</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spring Meeting</td>
</tr>
<tr>
<td></td>
<td>2007 Distinguished Achievement Teaching Award (College level)</td>
<td>Thomas D.J.</td>
<td>Texas A&amp;M University</td>
</tr>
<tr>
<td></td>
<td>2007 – 2009 Distinguished Lecturer</td>
<td>Herbert, B.E.</td>
<td>National Association of Geoscience Teachers</td>
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<tr>
<td></td>
<td>2007 Outstanding Educator Award</td>
<td>Ahr, W.M.</td>
<td>Gulf Coast Association of Geological Societies</td>
</tr>
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<td></td>
<td>2008 Palaeontological Association Hodson Award</td>
<td>Wade, B.S.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2008 Dean’s Research Achievement Award</td>
<td>M.E. Everett</td>
<td>Texas A&amp;M Geosciences</td>
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<td></td>
<td>2007 Jane and R. Ken Williams ’45 Chair in Ocean Drilling Science,</td>
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<tr>
<td></td>
<td>2007 Honorary Member</td>
<td>Bouma, A.H.</td>
<td>American Association of Petroleum Geologists</td>
</tr>
<tr>
<td></td>
<td>2007 Honorary Member</td>
<td>Bouma, A.H.</td>
<td>Society of Sedimentary Geology</td>
</tr>
<tr>
<td></td>
<td>2007-2008 Distinguished Lecturer</td>
<td>Hopper, J.R.</td>
<td>NSF Margins Program</td>
</tr>
<tr>
<td></td>
<td>2007 Finalist, John J. Koldus Award in Student Advising</td>
<td>M.E. Everett</td>
<td>Texas A&amp;M University</td>
</tr>
<tr>
<td></td>
<td>2007 Honorary Member</td>
<td>Bouma, A.H.</td>
<td></td>
</tr>
</tbody>
</table>
2007 Sidney Powers Memorial Award  
Bouma, A.H.  
American Association of Petroleum Geologists  

2007 Women's Faculty Network Mentoring Award  
Richardson, M.J.  
Texas A&M (University Level)  

2006  

2006 Distinguished Lecturer, National Association of Geoscience Teachers Big Bend VFT, Recommended resource for iGuide site, Encyclopedia Britannica Assessing Technology in Teaching Award, Office of Distant Education, TAMU.  
Herbert, B.E.  
National Association of Geoscience Teachers  

2006 Montague Scholar  
Olszewski, T.D.  
TAMU Center for Teaching Excellence  

2006 Elected to Life Member  
Mathewson, C.  
American Society of Civil Engineers,  

2006 Elected Fellow  
Mathewson, C.  
Society of American Military Engineers,  

2006 Faculty Fellow  
M.E. Everett  
Texas A&M Center for Heritage Conservation  

2006 GSA Fellow  
Zhan, H.  

2006 Geo-Legend  
Bouma, A.H.  
Houston Geological Society  

2006 Presidential Citation for Mentoring  
Mathewson, C.  
Association of Environmental and Engineering Geology, Annual Meeting, Boston, MA, (included Janet M. Mathewson).  

2006 Regents Professor  
Mathewson, C.  
Board of Regents, Texas A&M University System  

2006 Robert C. Runnels Excellence in Advising Award  
Mathewson, C.  
College of Geosciences, Texas A&M University,  

2005  

2005 Distinguished Achievement Award for Teaching (College Level)  
Ahr, W.M.  
Association of Former Students (Texas A&M)  

Herbert, B.E.  
National Association of Geoscience Teachers
2005 Recognized as the inventor of the Sun Model: Theoretical work on carbonate rock physics referred to as the Sun model and implemented by Shell Oil Company in its advanced seismic reservoir characterization technology. It is also known to other major national and international oil companies.
Sun, Y.

2003-2008 Earl Cook Professorship of Geosciences
Raymond, A.
College of Geosciences, Texas A&M University

2002-present M. T. Halbouty Chair in Geology, Witschko, D. V.
College of Geosciences, Texas A&M University

2002-2009 Mollie B. and Richard A. Williford Professorship Ray C. Fish Professorship in Geology,
Grossman, E.L.
College of Geosciences, Texas A&M University

2002-2007 Ray C. Fish Professorship in Geology
Kronenberg, A.K.
College of Geosciences, Texas A&M University

2002-present Robert R. Berg Professorship in Geology,
Ikelle, L.T.
College of Geosciences, Texas A&M University
Appendix G. Keynote and Invited Talks
2009


Everett, M.E. (2009) A review of controlled-source electromagnetics in the 0.2-1.0 km depth range, Fall AGU Meeting, San Francisco CA, December 14.


Grossman, E.L. (2009) Evolution of Cenozoic Climate and Ocean Chemistry Recorded in the Chemical and Isotopic Composition of Mollusk Shells Smithsonian Tropical Research Institute, Panama.


Mathewson, C. (2009) Minerals and Their Products, Cornerstone Christian Academy, College Station, TX, Grades 1 through 6, 27 February.


Sun, Y. (2009) Integrated Geological and Geophysical Reservoir Characterization and Reservoir Prediction Based on Rock Physics, China Petroleum and Chemical Corporation (Sinopec), Beijing, China, April 23-24.


Weiss, R (2009) Tsunami sediments from theoretical perspective, 24-September, USGS, Santa Cruz.


Zhan, H. (2009) Contaminant transport: Beyond the advection-dispersion equation (ADE), Combined Seminar 681 for Department of Civil and Environmental Engineering, Department of Biological and Agricultural Engineering, and Water Management and Hydrological Sciences Program, Texas A&M University, September 30.


Zhan, H. (2009) The difference of educational systems in the United States and China and their cultural origins—my 18 years observation, Department of Resources Engineering, National Cheng Kung University, Taiwan, July 25.


Zhan, H. (2009) *Unconfined aquifer flow: the myth and the truth*, the 8th IPACES annual meeting, China University of Geosciences, Beijing, China, June 29.


2008


Mathewson, C. (2008) Development of the ASBOG Geology Exam and its Use as an Exit Exam, invited seminar, Department of Geology, Baylor University, Waco, TX, 1 February.


Zhan, H. (2008) *What are aquitards and why we care about them*, Department of Geosciences, University of Texas at Dallas, April 24.

**2007**


Mathewson, C. (2007) *Geology and Soils of Texas*, Texas Master Naturalists Program, Brenham, TX, 12 February

Mathewson, C. (2007) *Minerals and Their Products*, Bremond Elementary School, Bremond, TX, 9 March


Wiltschko, D.V. (2007) *3D geometry of the Western Foothills fold and thrust belt from retrodeformable cross sections: Thin-skinned vs Thick-skinned?*, National Central University, Taiwan, Jan 29.

Zhan, H. (2007) *What are aquitards and why we care about them?* Congreso Binacional Del Agua, Saltillo, Coahuila State, Mexico, Nov. 29.


Zhan, H. (2007) *The dilemma of boundary conditions in column tracer tests*, School of Natural Resources and Environmental engineering, Hefei University of Technology, China, June 10.


2006


Zhan, H. (2006) *What is wrong with the advection-dispersion equation (ADE)?*, Department of Geological Sciences, University of Texas at Austin, Nov. 3.

Zhan, H. (2006) *What is wrong with the advection-dispersion equation (ADE)?*, Department of Geology and Geophysics, Texas A&M University, College Station, TX, Oct. 12.


2005


Chester, J.S. (2005) *Physical Limits to Earthquake Ground Motion in Rock: Fault Zone/Rupture Zone Geology*, Workshop on Physical Limits to Earthquake Ground Motion in Rock, Session on Fault Zone Geology, USGS/SCÉC, Palm Springs, CA, September 6-8.

Chester, J.S. (2005) SAFOD Core Logging Status Sampling Party IODP, First NSF sponsored San Andreas Fault Observatory at Depth (SAFOD) Core Sampling Workshop, College Station, TX, February 23.


Marcantonio, F (2005) Sediment focusing in the equatorial Pacific Ocean, Yale University, invited talk, November.


Zhan, H. (2005) Horizontal well dynamics and its application in stream-aquifer interaction, coastal aquifer management, and environmental remediation, the 5th IPACES annual meeting, Guangzhou, China, June 23.


Appendix H. Professional Activities

H.1. Editorships
2009

Paleobiology, 2009-present
Olszewski, T.D.
Associate Editor

Wiltschko, D. V.
Guest Associate Editor

Journal of Seismic Exploration, 2009
Ikelle, L.T.
Editorial Board

Journal of Hydrology, 2007-present
Zhan, H.
Associate Editor

Geobiology, 2009-present
Tice, M.M.
Editorial Board Member

Journal of Contaminant Hydrology, 2000-present
Zhan, H.
Associate Editor

2008

Engineering Geology Division, 2008-present
Giardino, J.R.
Publications Chair

2007

Tectonophysics Special Issue Drilling Into Fault Zones, 2007
Chester, F.M.
Co-Editor

Open Paleontology Journal, 2007-present
Wade, B.S.
Editorial Advisory Board Member

2006

Texas Lignite The Good, Bad and Ugly, 2006
Editor, Field Trip Guidebook Annual Meeting, Houston, TX, 13 April,
Mathewson, C.

Journal of Computational Acoustics, 2006-present
Sun, Y.
Associate Editor

International Journal of Coal Geology, 2006-present
Raymond, A.
Associate Editor
2005

AAPG Bulletin, 2004-present
Ahr, W.M.
Associate Editor

The Geological Journal, 2004-present
Ahr, W.M.
Editorial Board

Geology, 2003-2005
Chester, F.M.
Member Editorial Board

Geophysical Journal International, 2005-present,
M.E. Everett
Editorial Board

Geophysics, 1997-present,
M.E. Everett
Associate Editor

Geomorphology, 1996-present
Giardino, J.R.
Editorial Board

School Science and Mathematics, 2005-2008
Herbert, B.E.
Associate Editor

Physical Properties of Earth Materials
Newsletter, 2005
Kronenberg, A.K.
Editor

Lithos, 1998-2005
Lamb, W.M.
Associate Editor

Palaios, 2004-present
Olszewski, T.D.
Associate Editor

Palaios, 1998-present
Grossman, E.L.
Associate Editor

Water Resources Research, 2003-2005
Zhan, H.
Associate Editor
H.2. Proposal Review Panels
2009

*NSF Marine Geology & Geophysics Program*
- Carlson, R. L.
- Review Panel, 2009

*NSF Geophysics*
- Chester, J.S.
- Review Panel, 2009

*NSF Chilean Science Foundation*
- Weiss, R.
- Review Panel, 2009

*NSF-EAR Tectonics*
- Miller, B.V.
- Review Panel, 2009

*NSF-EAR Sed Geology and Paleobiology (SGP)*
- Olszewski, T.D.
- Review Panel, 2009

*NSF OCE Committee of Visitors*
- Thomas, D.J.
- Panel Member, 2009

*NSF RIDGE 2000 Program*
- Sparks, D. W.
- Review Panel, 2009

2008

*AAAS Research Competitiveness Program*
- M.E. Everett

*DOD SERDP MMR Program*
- M.E. Everett
- Review Panel, 2008

*NASA ROSES Earth Interiors Program*
- M.E. Everett
- Review Panel, 2008

*NSF MARGINS*
- Carlson, R. L.
- Review Panel, 2008

2007

*DOD/EPA/DOE “Strategic Environmental Research and Development Program (SERDP)*
- Zhan, H.
- Review Panel, 2007

*Southern California Earthquake Center*
- Chester, J.S.
- Review Panel, 2007
2006

**NSF Geophysics**
Chester, F.M.
Review Panel, 2006

**Petroleum Institute**
Ahr, W.M.
Abu Dhabi, UAE, 2006

**NSF Division of Undergraduate Education**
**Course, Curriculum and Laboratory Improvement**
Herbert, B.E.
Member, Review Panel in Geoscience, 2006

**USGS National Earthquake Hazards Reduction Program**
Chester, J.S.
Review Panel, 2006

2005

**Canadian National Sciences and Engineering Research Council**
Gibson, R.
Review panel, 2005

**DOE Proposal Review Panel**
McGuire, J.T.
Review Panel, 2005

**NSF Geophysics**
Chester, F.M.
Review Panel, 2005

**NSF, Geology and Paleontology, Geobiology and Environmental Geochemistry**
Grossman, E.L.
Review panel, 2002 - 2005

**NSF Marine Geology and Geophysics Program**
Thomas, D.J.
Panel Member, 2005

**Southern California Earthquake Center**
Chester, J.S.
Review Panel, 2005

**NSF Advanced Technology Education**
Herbert, B.E.
Member, Review Panel, 2005

**USGS National Earthquake Hazards Reduction Program**
Chester, J.S.
Review Panel, 2005
H.3. Memberships on National and International Committees
2009

Association of Environmental and Engineering Geologists
Mathewson, C.
Chair, Academic Survival Committee, 2009-present

Association of Environmental and Engineering Geologists
Mathewson, C
Continuing Education Committee, 2009-present

International Professionals for Advancement of Chinese Earth Science
Zhan, H.
Treasurer, 2009-2010

Integrated Ocean Drilling Program, Science Advisory Structure,
Sager, W. W.
Site Survey Panel, 2009

National Association of Geoscience Teachers
Herbert, B.E.
Councillor, Executive Committee, 2009-11

2008

College Board AP Environmental Science Standards
Herbert, B.E.
Reviewer, 2008-09

Earth Science Literacy Initiative
Herbert, B.E.
Panel member, 2008

D'TELO (Deep Time Earth Life Observatory) Initiative
Raymond, A.
Steering Committee Member, 2008-2010

NASA Working Group: Geomagnetism after SWARM
M.E. Everett
Committee Member, 2008

2007

NanTroSEIZE Project Management Team
Chester, F.M.
Committee Member, 2007-2008.

NSF San Andreas Fault Observatory at Depth (SAFOD)
Kronenberg, A.K.
SAFOD Core Sampling Committee, 2007-present
AGU Mineral and Rock Physics Committee
Kronenberg, A.K.
Chair, Fellows Nomination Committee, 2006-2008
Chair, Student Awards Committee, 2006-2007

AGU Near—Surface Focus Group
M.E. Everett
Executive Committee Member, 2006

College Board Science Standards for College Success Committee
Herbert, B.E.
Member, Earth Sciences, 2006-09

International Continental Drilling Program
Fox, P.J.
International Review Committee, 2006

International Professionals for Advancement of Chinese Earth Science
Zhan, H.
Chair of Publication Committee, 2006-present

Paleontological Society
Raymond, A.
Medal Committee, 2006-2009

Southern California Earthquake Center (SCEC)
Chester, J.S.

Sub commission on Carboniferous Stratigraphy, International Commission on Stratigraphy.
Grossman, E.L.
Corresponding member, 2006-present

System-Wide Change: An Experimental Study of Teacher Development and Student Achievement in Elementary Science, (SCALE). University of Wisconsin
Herbert, B.E.
Member, Advisory Board, 2006-present

Transportation Review Board, National Research Council, National Academies
Herbert, B.E.
Member, Committee on Physiochemical & Biological Processes in Soils, 2006-present
2005

AGU Mineral and Rock Physics Committee
Kronenberg, A.K.
Secretary of Executive Committee, 2004-2007
Student Awards Committee, 2004-2007
Executive Committee, 2004-2008

American Association of Petroleum Geologists
Mathewson, C.
Field Trip Safety Committee, 2005-Present

CHRONOS Project (NSF-funded informational technology project)
Grossman, E.L.
Member, Internal Coordinating Committee, 2004 - 2006
Geochemistry co-ordinator, (responsible for sedimentary geochemistry database and tools) (8/02 – 12/06)

Horton Research Grant Committee, American Geophysical Union
Zhan, H.
Chair, 2005-2006

National Association of State Boards of Geology
Mathewson, C.
2005 Task Analysis Committee, 2004-2005

National Association of State Boards of Geology
Mathewson, C.
National Council of Examiners, 1994-present

NSF San Andreas Fault Observatory at Depth (SAFOD)
Fox, P.J.
SAFOD Executive Advisory Board, 2005-2008

NSF Conference on Alternative Certification of Science Teachers
Herbert, B.E.
Member, Advisory Board, 2005

Paleobiology Database - Paleobotany Working Group
Raymond, A.
Steering Committee Member, 2002 - present

Paleontological Society Council
Raymond, A.
Councilor-at-Large, 2005-2007

Paleontological Society Student Awards Committee 2004-2005
Raymond, A.
Member, 2004-2005
San Andreas Fault Observatory at Depth (SAFOD)
   Chester, F.M.
   *Science Team Member*, 2004-2007

Society of American Military Engineers
   Mathewson, C.
   *Texas A&M Student Chapter*, Houston Post, 2003 – present

Society of Exploration Geophysicists
   Gibson, R.,
   *Research Committee*, 1998-present

Southern California Earthquake Center (SCEC)
   Chester, J.S.

Southern California Earthquake Center External Advisory Board
   Miller, K.C.
   *Board Member*, 2005-present

TAMU Delegation to Universities Council on Water Resources, UCOWR
   Herbert, B.E.
   *Member*, 2005-present

U.S. Science Advisory Committee for the Integrated Ocean Drilling Program
   Sager, W.W.
   *Committee member*, 2005 - 2007
H.4. Workshop Participation
Aquifer Characterization and Testing
Mathewson, C. (Instructor 16-hour course)
Texas Engineering Extension Service, Riverside Campus, 11 – 12 March, 11 – 12 August, 2009

Dynamic Weakening Mechanisms Workshop
Chester, J.S.
Chair, Southern California Earthquake Center, Palm Springs, CA, Sept. 12-13, 2009

EarthScope/Cascadia workshop
Carlson, R. L.
Lamont-Doherty Earth Obs, Palisades, NY, June, 2009

EarthTime IV Workshop, Denver, CO.
Miller, B.V.
Participant, Mar. 1-3, 2009

Groundwater Assessment,
Mathewson, C. (Instructor 3-hour course)
Environmental Assessment Program,
Texas Engineering Extension Service, Riverside Campus, 26 February, 2009

ISEC Community Workshop: Simulation & Large-Scale Testing of Nearshore Wave Dynamics
Weiss, R.
Participant, Corvallis, Oregon, July 8-10, 2009

Introduction to Hydrogeology,
Mathewson, C. (Instructor 16-hour course)
Texas Engineering Extension Service, Riverside Campus, 13-14 January, 3 – 4 February, 2009

MGDS GeoInformatics Meeting
Carlson, R. L.
Lamont-Doherty Earth Obs, Palisades, NY, Jan, 2009

MARGINS Steering Committee
Carlson, R. L.
National Science Foundation, Washington, D.C., March, 2009

Everett, M.E.
Participant, 2009

Professional Ethics,
Mathewson, C. (Instructor 1-hour course)
Texas Commission on Environmental Quality, Austin, Texas,
Texas Engineering Extension Service, 18 June, 2009

R/V Marcus Langseth mini-workshop: Providing greater access to new 3D seismic datasets
Gibson, R.
Participant, Denver Aug 12-13, 2009
Ridge 2000 Workshop
   Carlson, R. L.
   *Participant*, St. Louis MO, Oct, 2009

Soil and Groundwater Remediation,
   Mathewson, C. (*Instructor 16-hour course*)

2008

3D Rupture Dynamic Code Validation Workshop
   Duan, B.
   *Invited speaker*, southern California Earthquake Center, November 17, 2008

Aquifer Assessment
   Mathewson, C. (*Instructor 3-hour course*)
   Environmental Assessment Program
   Texas Engineering Extension Service, Riverside Campus, 17 April, 2008

Extreme Ground Motion Workshop
   Duan, B.
   *Invited speaker*, southern California Earthquake Center, September 6-7, 2008

Fault Zone Structure and Mechanics Workshop
   Chester, J.S.
   *Co-Chair and Speaker*, Southern California Earthquake Center, Session Palm Springs, CA, June 11-12, 2008

Introduction to Hydrogeology
   Mathewson, C. (*Instructor 16-hour course*)
   Corrective Action Program Managers
   Texas Engineering Extension Service, Riverside Campus, 18-19 March, 2008

Newport-Inglewood Fault Drilling Workshop, SAFOD Overview
   Chester, J.S.

Oligocene Planktonic Foraminifera, Working Group Meeting
   Wade, B.S.
   *Chair*, ExxonMobil, Houston, 9-10 October, 2008.

   Gibson, R.
   *Participant*, Austin, TX, 27-31 July, 2008

Ridge 2000 Lua Basin ISS Workshop,
   Carlson, R. L.
   *Participant*, Salt Lake City, UT, Sept., 2008
Ridge 2000 Endeavour ISS Workshop,
Carlson, R. L.
*Participant*, Seattle, WA, Sept., 2008

Ridge 2000 EPR ISS Workshop,
Carlson, R. L.
*Participant*, Falmouth, MA, Sept., 2008

Soil and Groundwater Remediation
Mathewson, C. (*Instructor 16-hour course*)
Corrective Action Program Managers
Texas Engineering Extension Service, Riverside Campus, 28-29 May, 4 – 6 June, 2008

Soil and Groundwater Remediation
Mathewson, C. (*Instructor 16-hour course*)
Corrective Action Program Managers
Texas Engineering Extension Service, Riverside Campus, 11-12 November, 18 – 20 November, 2008

Stratigraphy, Paleoclimate, Paleoecology of Pennsylvanian Coals in North America,
Raymond, A.

The Next Decade of the Seismogenic Zone Experiment Workshop
Chester, F.M.
*Invited Speaker*, NSF MARGINS Program, SEIZE Workshop, Mt. Hood, Oregon, September, 2008

2007

Aquifer Testing and Characterization
Mathewson, C. (*Instructor 16-hour course*)
Texas Commission on Environmental Quality, Austin, TX,
Texas Engineering Extension Service, 21-22 August, 7 – 8 November, 2007

Hotspots Geodynamics Detailed Planning Group Workshop
Sager, W.W.
*Participant*, University of Hawaii, Honolulu, January 25-27, 2007

Introduction to Hydrogeology
Mathewson, C. (*Instructor 16-hour course*)
Corrective Action Project Managers
Texas Engineering Extension Service, Riverside Campus, TX, 27-28 March, 2 – 3 August, 2007

Wade, B.S.
*Invited speaker*, Kiel, Germany, 10-12 October, 2007
Multidisciplinary workshop on Southern South American Dust, CENPAT, Puerto Madryn, Argentina, Marcantonio, F
   Participant, October 3-5, 2007

NSF sponsored San Andreas Fault Observatory at Depth (SAFOD) Workshop
Chester, J.S.

Oligocene Planktonic Foraminifera, Working Group Meeting
Wade, B.S.
   Chair, Tübingen, Germany, 14-16 December, 2007

Oligocene Planktonic Foraminifera, Working Group Meeting
Wade, B.S.
   Chair, Croatia, 12-18 May, 2007

San Andreas Fault Observatory at Depth (SAFOD) Workshop
Chester, F.M.

Soil and Groundwater Remediation
Mathewson, C. (Instructor 16-hour course)
Corrective Action Project Managers

Topical Session T110. Combining Kinematics and Mechanics in Understanding Deformation Processes
D. V. Wiltschko
   Chair and co-convenor (invited)
Geological Society of America Annual Mtg, 2007

2006

Aquifer Testing and Characterization
Mathewson, C. (Instructor 16-hour course)
Corrective Action Project Managers
Texas Engineering Extension Service, Riverside Campus, TX, 31 January-1 February, 26-27 April, 22-23 August, 2006

EarthScope/GeoFrame Workshop. St. Louis, MO.
Miller, B.V.
   Participant, Feb. 3-5, 2006

EarthTime III Workshop, Santa Fe, NM.
Miller, B.V.
   Participant, Sept 10-12, 2006

Future Research Directions in Paleontology (FRDP), Smithsonian Institute
Raymond, A.
   Participant, Apr. 8-9, 2006
IODP-ICDP Fault Zone Drilling Workshop  
Chester, F.M.  
*Invited Speaker*, Miyazaki, Japan, May, 2006

Introduction to Hydrogeology  
Mathewson, C. (*Instructor 16-hour course*)  
Corrective Action Project Managers  
Texas Engineering Extension Service, Riverside Campus, TX, 21-22 March, 2006

Mission Moho Workshop  
Carlson, R.L.  
*Participant*, Portland OR, Sept. 2006

Oligocene Planktonic Foraminifera, Working Group Meeting  
Wade, B.S.  
*Chair*, Forams 2006, Brazil, September, 2006.

http://www.dosecc.org/html/newsletters.html Workshop and Field Trip  
Chester, J.S.  
*Chair*, DOSECC and SCEC, Palm Springs, CA, and southern CA field trip, Sept. 9-10, 2006

Paleobiology Data Base Paleobotany Working Group, Smithsonian Institute,  
Raymond, A.  
*Steering Committee Member*, Apr. 10-12, 2006

Soil and Groundwater Remediation  
Mathewson, C. (*Instructor 24-hour course*)  
Texas Commission for Environmental Quality Austin, Texas,  

Surface Earth Process Cyberinfrastructure, Workshop  
Herbert, B.  

Tanzania Drilling Project, Postdrilling Meeting  
Wade, B.S.  
*Participant*, Cardiff, June 26-30, 2006

2005

Aquifer Testing and Characterization  
Mathewson, C. (*Instructor 16-hour course*)  
Texas Commission on Environmental Quality Austin, TX  

Biogeochemical Processes at River-Ocean Margins, Workshop, RIOMAR, Mandeville, LA.  
Marcantonio, F  
*Participant*, November 5-7, 2005
CHRONOS Strategic Planning meeting, Ames, IA.
Grossman, E.L.
Participant, 2005

EarthTime II Workshop, Dedham, MA.
Miller, B.V.
Participant, Oct 22-24, 2005

Geochemical Proxies Workshop
Thomas, D.J.
Participant, NSF Workshop, Dec. 10-22, 2005

Integrating Research & Education, VPR Earth & Environmental Sciences Agencies (NSF, NASA, NOAA, USDA, DOE) Seminar
Herbert, B.
Participant, Texas A&M, 2005

Introduction to Hydrogeology
Mathewson, C. (Instructor 16-hour course)
Texas Commission on Environmental Quality, Austin, TX
Texas Engineering Extension Service, 15-16 March, 2005

Introduction to Hydrogeology
Mathewson, C. (Instructor 16-hour course)
Corrective Action Project Managers
Texas Engineering Extension Service, Riverside Campus, TX, 19-20 April, 2005

Mechanics in Structural Geology Workshop
Chester, F.M.
Invited Speaker, ExxonMobil Upstream Research Co, Houston, TX, February, 2005

NSF-sponsored workshop on Environmental Proxies, San Francisco (“Geoinformatics: What emerging IT systems can do for you”)
Grossman, E.L.
Steering Committee and speaker, 2005

NSF-Sponsored Workshop “Resolving the Late Paleozoic Gondwanan Ice Age in Time and Space”, Salt Lake City, Utah,.
Pope, M.C.
Participant, October 20-21, 2005

Oligocene Planktonic Foraminifera, Working Group Meeting
Wade, B.S.
Chair, Smithsonian National Museum of Natural History, Washington D.C., 15-18 November, 2005

Paleobiology Data Base Paleobotany Working Group, National Center for Ecological Analysis
Raymond, A.
Steering Committee Member, Mar. 13-16, 2005
Physical Limits to Earthquake Ground Motion in Rock, Session on Fault Zone Geology Workshop
Chester, J.S.
*Invited Speaker*, USGS/SCEC sponsored, Palm Springs, CA, Sept. 6-8, 2005

Recent Advances in Fault Zone Studies and their Impact on Earthquake Source Processes Workshop and Field Trip
Chester, F.M.
*Co-Leader*, Southern California Earthquake Center, Palm Springs, California, Sept. 14-16, 2005

San Andreas Fault Observatory at Depth (SAFOD) Core Sampling Workshop
Chester, J.S.
*Invited Speaker*, College Station, TX, February 23, 2005

San Andreas Fault Observatory at Depth (SAFOD) Core Sampling Workshop
Chester, F.M.
*Participant*, Menlo Park, CA, December 3, 2005

San Andreas Fault Observatory at Depth (SAFOD) Core Sampling Workshop
Chester, F.M.
*Participant*, College Station, TX, February 23, 2005

San Andreas Fault Observatory at Depth (SAFOD) Core Sampling Workshop
Chester, J.S.
*Invited Speaker*, Menlo Park, CA, December 3, 2005

San Andreas Fault Observatory at Depth (SAFOD) Core Sampling Workshop
Wiltschko, D.V.
*Participant*, College Station, TX, February 23, 2005

Society of Exploration Geophysicists, Development and Production Committee Workshop. Attenuation: What's to Gain from Seismic Loss
Gibson, R.
*Participant*, Austin, TX, 15-19 May, 2005

Special Session on “The Dynamics of Crustal Permeability: From Syntectonic Veins to Earthquakes”
D. V. Wiltschko
*Chair and co-Convener*, American Geophysical Union, Fall Meeting, Dec. 5-9, 2005

TAMU Faculty Forum, Seeking Synergy Through the Integration of Research & Education
Herbert, B.
*Invited Participant*, Texas A&M., 2005

Tanzania Drilling Project, Postdrilling Meeting
Wade, B.S.
Understanding What Our Geoscience Students Are Learning: Observing and Assessing Herbert, B.

*Invited Participant*, Carleton College, Northfield, MN., 2005
H.5. Conferences and Special Sessions
2009

*Geomagnetic induction in the Solid Earth and Ocean*
M.E. Everett
Invited Session Chair, 2nd SWARM Science Meeting, Potsdam, Germany, May 10, 2009

*Electromagnetic Induction Studies*
M.E. Everett
Invited Session Chair, SAGEEP 2009, Fort Worth TX, March 31, 2009

*Near-Surface Geophysics General Contributions*
M.E. Everett
Invited Session Chair, AGU Fall Meeting, San Francisco CA, December 14, 2009

*New Perspective on the Development of the Western Cordilleran margin,*
Pope, M. C.
Co-Chair (with Chris Fedo), National Meeting Geological Society of America, Oct. 18-21, 2009

*Non-Darcian and Non-Richards Flow in Porous Media*
Zhan, H.
Co-Chair, Section H43, AGU Fall Meeting, 2009

*Reconstruction of Paleoclimate Theme, Goldschmidt Conference Organizing Committee*
Grossman, E.L.
Co-chair (Grossman and Lear) of theme (organizer of special sessions), 2009

*Reservoir Geophysics*
Sun, Y., Chair, Joint International Geophysical Conference and Exposition Chinese Petroleum Society (CPS) and Society of Exploration Geophysicists (SEG), April 24-27, 2009

*Science Discussion: What field and laboratory observations are most crucial for validating models of stress evolution and rupture dynamics?*
Chester, J.S.
Session Moderator, Southern California Earthquake Center Annual Meeting, Sept. 15, 2009

*Special Session on Fault Zone Processes*
Chester, J.S.
Chair, EarthScope National Meeting, Boise, ID, May 12-13, 2009

*Symposium on Experimental Taphonomy*
Raymond, A. and K. Parsons-Hubbard Chairs
North American Paleontological Convention, Jun. 21-26, 2009

2008

*Research Advances on the Geologic, Tectonic, and Geochemical Evolution of the Indian Ocean Seafloor and Its Margins II, Special Session T53G,*
Sager, W. W., Co-chair
Fall AGU Meeting, San Francisco, December 19, 2008
Science Plan Discussion: FARM  
Chester, J.S.  
Session Chair, Southern California Earthquake Center Annual Meeting, Sept. 9, 2008

Special Session: Geochemical tracers of changes in seawater chemistry  
Marcantonio, F., Co-Chair  
National Meeting Geological Society of America, Oct. 5-9, 2008

Special Session on Non-Darcian Flow and Non-Fickian Transport in Porous and Fractured Media  
Zhan, H.-B.  
Chair, National Meeting Geological Society of America, Oct. 5-9, 2008

Hydrogeology II-Groundwater, Non-Darcian Flow, and Nomenclature,  
Zhan, H.  
Co-Chair, T 313 GSA annual meeting, Houston, Texas, USA, Oct 5-9, 2008

Topical session: Advances in Discontinuum Numerical Modeling in the Study of Earth Structure and Deformation  
J. Morgan (Rice Univ.), P. McGovern (LPI), D. W. Sparks  
Co-organizers: National Meeting Geological Society of America, Oct. 5-9, 2008

Topical Session on Breaking the Curve: Historical Development, Current State, and Future Prospects for Understanding Local and Regional Processes Governing Global Diversity.  
Olszewski, T.D.  
Geological Society of America Joint Meeting, Houston, TX., 2008

Teaching and Learning about Complex Earth Systems: Effective Strategies in Undergraduate Classrooms and Teacher Development Programs  
Herbert, B. and K. McNeal  
Organizer, National Meeting Geological Society of America, Oct. 5-9, 2008

2007

Science Plan Discussion, Session III and: FARM  
Chester, J.S.  
Session Chair, Southern California Earthquake Center Annual Meeting, Sept. 11, 2007

Geohazards, the 6th IPACES annual meeting, Wuhan, China, June 27, 2007  
Zhan, H.  
Co-Chair

Theme Session on Isotopic Geochemistry and Geobiology in the Permo-Carboniferous  
Grossman, E.L. and H-S. Mii  
XVI Intl. Congress on the Carboniferous and Permian, Nanjing, China, 2007

2006

Flow and Transport in Aquitard-Aquifer system,  
Zhan, H.  
Science Plan Discussion, Session III: FARM
Chester, J.S.
Session Chair, Southern California Earthquake Center Annual Meeting, Sept. 12, 2006

Advances in Subsurface Flow and Transport: Eastern and Western Approaches II
Zhan, H.
Co-Chair, Western Pacific Geophysics Meeting, Sections H44E, Beijing, China, July 24-27, 2006

Advances in Subsurface Flow and Transport: Eastern and Western Approaches III,
Zhan, H.
Co-Chair, Western Pacific Geophysics Meeting, Sections H45A, Beijing, China, July 24-27, 2006

Special Session on Using Detrital Zircon Geochronology To Answer Geological Questions We Formerly Could Not Ask
Pope, M.C.
Co-Chair (with Paul Link), National Meeting Geological Society of America, Oct. 22-25, 2006

Special session in Extinction, Dwarfing and the Lilliput Effect
Wade, B.S.
Co-Chair, National Meeting Geological Society of America, Philadelphia, Oct., 2006

Special Session on Quantifying Subsurface Biogeochemical Processes: Innovative Field Experiments and In Situ Measurement Techniques
McGuire, J.T.
Chair and Organizer, Spring Joint Assembly, American Geophysical Union, 2006

2005

Bays and Estuaries of the northern Gulf of Mexico, Special Session, Geological Society of America,
South Central Regional Meeting, San Antonio, TX,
Sager, W. W., Co-chair.
April, 1-2, 2005

Clays and Environmental or Ecological Processes.
Herbert, B.E.
Session Chair, Clay Minerals Society National Meeting, 2005

FARM Plenary Session II
Chester, J.S.
Session Co-chair, Southern California Earthquake Center Annual Meeting, Sept. 12, 2005

Beyond Theis and Hantush: New Advances in Aquifer and Aquitard Characterization I
Zhan, H.
Co-Chair, AGU Fall Meeting, Section H32A, 2005

Hydrogeology II: Modeling and Parameter Measurement
Zhan, H.
Co-Chair, GSA annual meeting, Section 238, Salt Lake City, Oct. 16-19, 2005

460
Southern California Earthquake Center Leadership Retreats
Chester, J.S.
Speaker and Moderator, Palm Springs and Oxnard CA, June 2005-2009

Special Session on Mechanisms of Continental Extension
Hopper, J.R.
Chair and Convener, American Geophysical Union, Fall Meeting, Dec. 5-9, 2005

Special Session on Radiated Energy and the Physics of Earthquake Faulting
Chester, J.S.
Program Committee Member, AGU Chapman Conference, Portland, Maine, June 13-17, 2005
http://www.agu.org/meetings/chapman/chapman_archive/cc05dcall.html

Special Session on New isotope tools in paleoclimatology
Marcantonio, F., Co-Chair
National Meeting AGU, 2005

Theme Session on GeoSystems and CHRONOS: Probing Earth's Deep-Time Climate and Linked Systems
Grossman, E.L. (Soreghan, Grossman, McArthur
Earth System Processes II, Calgary, Canada, 2005
H.6. Consultancies
2009
ETC Texas Pipeline, Ltd. v. T C and C Real Estate Holdings, Inc.; Cause No. 27,197-B; 87th, 2009
Mathewson, C.
Judicial District Court, Limestone County, Texas: Attorney: Steven R. Sampson, Barron, Adler &
Anderson, L.L.P., San Antonio, Texas

Evaluating Tenure and Promotion package, 2009
Zhan, H.
Colorado School of Mines

Evaluating Tenure and Promotion package, 2009
Zhan, H.
Wayne State University

Stable isotope analyses, 2009
Grossman, E.L.
Anadarko/Devon partnership

2008
Advanced Carbonate Reservoir Geology Short Courses, 2008
Ahr, W.M.
Algerian National Oil Co., Algiers

Advanced Carbonate Reservoir Geology Short Courses, 2008
Ahr, W.M.
Petrobras, Brazil

Advanced Carbonate Reservoir Geology Short Courses, 2008
Ahr, W.M.
Maylasian National Oil Co., Kuala Lumpur

Consultancy on development of borehole radar imaging tools, 2008
M.E. Everett
Hexion Oilfield Technology, Houston, TX

Consultancy on Electromagnetic Detection of Underground Storage Tanks, 2008
M.E. Everett
Malcolm Pirnie Inc., Houston TX

Consultancy on Ground-penetrating radar mapping of cemetery, 2008
M.E. Everett
Old Waverly Cemetery Association, Old Waverly TX

Consultancy on Anisotropic Ray Tracing, 2007-2008
Gibson, R.
CGGVeritas, Houston, TX
Consultancy on rock-physics-based seismic reservoir characterization, 2008
Sun, Y.
Devon Energy Corporation, Houston, TX

Danny Crump and Billie Ann Crump v. TXU Generation Management Company, L.L.C.; TXU Generation Company, L.P. a/k/a TXU Energy; TXU Mining Management Company, L.L.C; TXU Mining Company, L.P. a/k/a TXU Energy and the Railroad Commission of Texas; Cause number GN4-02977
Mathewson, C.

Evaluating Tenure and Promotion package, 2008
Zhan, H.
University of Utah

Evaluating Tenure and Promotion package, 2008
Zhan, H.
University of Nevada, Reno

Kinematic and mechanical reconstruction of Walker Ridge structures, deepwater Gulf of Mexico, 2008
Wiltschko, D. V. in support of Tosin Majekodunmi
Hess Petroleum, Houston

Sequence Stratigraphy of Devonian Rocks of Montana and Idaho, 2008
Pope, M.C.
Prisem Geoscience Consulting, Spokane, WA.

2007
Advanced Carbonate Reservoir Geology Short Courses, 2007
Ahr, W.M.
Thai National Oil Co., Bangkok

Consultancy on foraminifera, 2007
Wade, B.S.
Stoney Forensics Inc.

Evaluating Tenure and Promotion package, 2007
Zhan, H.
University of Kansas and Kansas Geological Survey

Evolution of the fold and thrust belt of Taiwan, 2007
Wiltschko, D. V., in support of Fernando Rodriguez-Roa
Conoco/Phillips

Sedimentation of a saltwater tidal wetland, Pine Gully, 2007
Mathewson, C.
City of Seabrook
2006

Advanced Carbonate Reservoir Geology Short Courses, 2006
Ahr, W.M.
PDVSA, Venezuela

Advanced Carbonate Reservoir Geology Short Courses, 2006
Ahr, W.M.
Sonangol, Angola

Consultancy on marine controlled-source electromagnetic software development, 2006
M.E. Everett
Geosystem, Milan, Italy

Expert Witness on seabed logging patent dispute, 2006
M.E. Everett
Ohm Seafloor Mapping, plc, Aberdeen, UK

Fracturing in the Candilejas, Columbia, 2006
Wiltschko, D. V.
Occidental Petroleum, Houston, TX

Identification of Potential Risks Due to Sulfate-Induced Damage in Lime-Stabilized Soils Along The SH-130 Corridor, 2006
Bruce E. Herbert, P.G., and Dallas N. Little, P.E.
Ferrovial, Austin Texas

2005

Consultancy on rock-physics-based seismic reservoir characterization, 2005
Sun, Y.
Shell Oil Company, Houston, TX

Renda Marine, Inc. vs. The United States Brian W. Erikson, Attorney, 2005
Mathewson, C.
The Erikson Firm, Dallas, TX; Case Number 02-306C, United States Court of Federal Claims, Trial March

River Place Subdivision lake leakage; -CV, Charles M. Gray and others vs Robert S. Smith and ROBO Investments, Inc. Cause No. 03-001121
Mathewson, C.
District Court of Brazos County, Texas, 361st Judicial District, Attorney, Bryan Cantrell, Cantrell, Ray and Maltsberger, Settled June 2005.
Appendix I. External Ph.D Program Review 2002
EXECUTIVE SUMMARY

The Department of Geology and Geophysics at Texas A & M University (TAMU) possesses considerable across-the-board strengths in many aspects of Earth science. It is administratively well positioned to undertake 21st century pioneering research and teaching activities in studies of the geologic environment, global climate change, national energy sufficiency, and coastal margins geo-ecology. However, progress is being presently hindered by the lack of a clear focus and a vision for the future. The “business as usual” attitude must be changed in order for the Department to achieve national prominence. In addition, increased efforts—both intellectual and financial—will be required to increase the quality of the now modest graduate student application pool. Our specific recommendations are as follows:

1) Define a new and compelling vision for scientific research and education that is capable of positioning the Department among the top-tier peer institutions. The vision should involve one or two major crosscutting intellectual themes that have important societal impacts. These scientific thrusts ought to build on areas of traditional strengths, harness the potential synergisms in the Department, College and University, and address the key elements of the Vision 2020 academic goals.

2) Build on existing scientific visibility and fund-raising potential to provide the extramural, private donor resources necessary to fuel the transformations that must take place in the next decade in order to fulfill that vision.

3) Develop a strategic hiring plan, compatible with the goals and objectives of the new directions, with emphasis on hiring bright young faculty, helping existing faculty develop and meet new expectations for entrepreneurial activity and increasing level of grant and contract funding.

4) Define and recruit one or more “transforming individuals” who will lead the intellectual theme areas outlined above. Such individuals would be experienced and nationally visible scientists with proven research and administrative reputations.

5) Restructure the graduate program, recognizing the contrasting needs of both professional students and research-oriented students.

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1 University of New Mexico
2 Colorado School of Mines
3 Ohio State University
4 Stanford University
6) Take steps to upgrade the overall quality of the graduate students and the graduate program, employing: (a) a much-more aggressive and targeted recruiting strategy that includes rapid, effective feedback to applicants; (b) a much-more-competitive financial package that leverages research assistantships, extends the funding for the full calendar year and recognizes research accomplishments; and (c), a substantial reduction in the time required to complete the degree.

7) Formula-based allocations for setting budgets should reflect research accomplishments and progress toward the Vision 2020 strategic goals as well as weighted student credit hours. The formula must provide incentives and rewards for achieving higher levels of research quality and productivity by providing special appropriations above and beyond the formula for targeted initiatives.

8) Develop a long-term plan for acquisition of shared, state-of-the-art instrumentation and facilities appropriate to a top-tier geoscience department. Collaboration with other departments, especially within the College of Geosciences, is critical for the implementation of this long-range instrumentation/equipment plan.

PREAMBLE

The external review committee for the Department of Geology and Geophysics was requested to evaluate the strengths and weaknesses of the Ph.D. program. Addressing this charge, however, necessitated a more general review of the Department as a whole. The committee met with the faculty and graduate students of the Department, Chairs of other departments in the College of Geoscience, Deans, and the Provost. The schedule is included as an APPENDIX. To facilitate this review, the Department prepared a detailed and comprehensive study document prior to our committee visit.

The Department of Geology, established in 1922, and the Department of Geophysics, founded in 1966, merged to form the present Department of Geology and Geophysics in 1994. The combined academic unit has an outstanding scholarly and industrial reputation, built on historical strengths in petroleum geoscience, geodynamics, and engineering geology. Recent hires have been particularly successful in raising the academic reputation of the Department. The faculty consists of 26 FTE, with four tenure-track searches now in progress. If all are successful, the Department will consist of 29 FTE (26 + 4 new –Joel Watkins retirement) not counting associated faculty from related departments; this total, however, represents a substantial contraction from a mid-1990s level of 37 FTE.

STATUS OF THE PROGRAM

The Department of Geology and Geophysics is extremely fortunate in being administered within the College of Geosciences, which facilitates interactions with the associated geoscience departments of Atmospheric Sciences, Geography and Oceanography. Moreover, research entities including the Geochemical Environmental Research Group (GERG), the Ocean Drilling Program (ODP), and the Texas A & M Sea Grant Program are also under the aegis of the College. Joint research and teaching thrusts are underway among Geology and Geophysics and
most of these organizations, and with the Department of Petroleum Engineering in the College of Engineering, as well as with the Institut Francais de Petrol (Paris). New initiatives authorized by the TAMU Administration represent additional teaching/research opportunities in the collaborative, interdisciplinary topics embodied in the proposed Center for Immersive Imaging, and the Sustainable Coastal Margins Program. Clearly, the possibilities for innovative, cross-disciplinary scientific activities are both numerous and promising for Geology and Geophysics faculty and student involvement.

Private-source research funding through industrial associates programs and oil company instrumentation/software gifts provide substantial additional support for the research and instructional efforts in several important areas: (1) the Petroleum Studies Laboratory; (2) the Center for Automated Seismic Processing; (3) The Center for Tectonophysics; and (4) the Integrated Reservoir Investigation Group. Moreover, the Department of Geology and Geophysics has been successful in attracting new endowments during the Expanding Excellence Capital Campaign ($11 M of which 3.5M has already been received).

Impediments along the road to scientific excellence traveled by the Department of Geology and Geophysics, however, have been imposed inadvertently by the TAMU Administration’s redistribution of resources according to an algorithm dominated by weighted student credit hour (WSCH) production of the College. While the attempt to treat all academic units fairly accords well with the State of Texas approach to providing funding to institutions within the university system, its local application fails to take into account the degree of achievement of the twelve goals of “Vision 2020: Creating a Culture of Excellence.” Moreover, a formulaic, quantitative dispersing of resources based on WSCH production neglects the measurement of quality—a prized characteristic all academic institutions attempt to maximize.

STRENGTHS OF THE GEOLOGY AND GEOPHYSICS DEPARTMENT

1) The Department has wide visibility in the petroleum industry as a major educational and research unit. Many fruitful connections with industry exist, providing internships and career employment to a large number of Geology and Geophysics graduates.

2) The Department of Geology and Geophysics enjoys a unique relationship with alumni involved in the exploration, discovery, and development of oil and gas resources. The intense loyalty of alumni continues to promote significant corporate and individual gift giving to the Department. Their generous support is reflected in the building, laboratories, and equipment.

3) Traditions and institutional devotion are exceptionally strong at TAMU overall, and in the geosciences as well. The Department and College clearly recognize the benefits of a historically strong connection to Texas and the petroleum industry.

4) The facilities and equipment/instrumentation are abundant, available, and reasonably modern. Teaching facilitates are outstanding. State-of-the-art capabilities exist in rock deformation, and a good base for aqueous analysis is in place. The building is well located and well designed; it is capable of accommodating substantially increased analytical capabilities.
5) The infrastructure for both undergraduate and graduate student teaching and research activities is remarkable; especially notable are the presence of highly accessible common space, abundant and state-of-the-art computer facilities, and—at least for graduate students—financial aid (fellowships, ubiquitous TA support).

6) The faculty has across-the-board strengths in a wide range of research thrusts. A pinnacle of excellence is currently extant in the Center for Tectonophysics; in the past, and continuing to the present, this center has attracted outstanding graduate students, and produced well-recognized research results. Potentially, centers of excellence and national prominence exist in several other areas: Petroleum Geology and Geophysics; Environmental Geochemistry and the Sustainable Development of Coastal Margins; and in Environmental Geophysics.

7) Over the past decade, outstanding young faculty members have been recruited at the beginning tenure-track level. The senior faculty is to be commended for wisdom in recruiting a remarkable group of able Earth scientists/instructors. These Assistant and Associate Professors are the stakeholders of the Departmental future, and must now step forward into academic leadership roles.

8) An unusual potential for synergism reflects the organization of the College of Geosciences: Oceanography, Geography, Atmospheric Sciences, and Geology and Geophysics all exist within this administrative unit, allowing the ready interdisciplinary cooperation in both instruction and research. Moreover, exceptional opportunities exist for joint programs with the Ocean Drilling Program and with the Geochemical Environmental Research Group. Much of this strength is virtual rather than actual, because the full opportunities for collaboration have not yet been realized (although several faculty members have built well-traveled bridges).

**WEAKNESSES OF THE GEOLOGY AND GEOPHYSICS DEPARTMENT**

1) The breadth of activities in the Department, while remarkably diverse, lacks a clear focus with a unified, inclusive vision for the future. More than 20 individual, unrelated or only weakly synergistic projects reflect a dozen stated research emphases. Development of a coherent vision is absolutely necessary to plan for future hires, shared laboratory facilities, and for fund-raising themes.

2) Graduate student capabilities and interests are incommensurate with those of a top-tier research university. Some students appear to view their graduate education as simply training—in effect, a trade school for the oil industry. The large number of MS candidates relative to doctoral students is not the most effective mix for a research-oriented institution. Our perception was that graduate student interests are less broad than are those of the faculty.

3) The graduate student applicant pool is inadequate in terms of both quality and quantity. This problem may be a consequence of low TA stipends or an insufficient amount of extramural Research Assistant funding. As a consequence, the breadth and depth of graduate student research activity suffers.
4) The structure of graduate programs (time-consuming TA duties combined with the need to take summer internships, in many cases unrelated to students' research) prompts unusually long, undesirable residence times to the terminal degree. Top-tier Universities both facilitate and demand a much more intense focus and effort on research by graduate students.

5) The overall level of grant and contract funding is not competitive with a nationally ranked research institution. The top ten state-funded research universities attract far more support per capita.

6) The Department includes accomplished Earth scientists but lacks a critical mass of senior faculty functioning as practical leaders effecting positive change. This problem is reflected in a paucity of collaboration and integration as well as in the near-absence of crosscutting, interdisciplinary programs.

7) There is a shortage of state-of-the-art analytical equipment essential to a top-tier department. The most important causes include: (a) TAMU-wide limitation of resources, especially those required for starting up new faculty; (b) a shortage of extramural grant and contract funds; and (c), a lack of coordination among geoscience departments to provide College-wide infrastructure and equipment/instrumentation.

NEED FOR A SHARED VISION

The Departmental self-study provides a wealth of information regarding the recent research activities and the cumulative scholarly accomplishments of its diversified faculty. Yet the document reflects a lack of a clear map toward significant improvement in standing to a top-tier Geology and Geophysics unit. Historical strengths in key areas (including a well-established and nationally recognized tradition in petroleum-related research and education) are not nearly sufficient to propel the Department to national prominence. There is an evident need to establish a new Departmental image more closely matching current research activities and goals—both internally at TAMU and within the State of Texas, and externally to the national and international geoscience community. But what is the new image? What is realistic, desirable, attainable and compatible with existing strengths and opportunities?

The Geology and Geophysics Departmental self-study highlights the apparent lack of focus. The overview lists 23 “thematic focus areas” and enumerates 12 “principal research thrusts.” This approach, while honoring each (and virtually every) individual’s particular contribution, does not sufficiently articulate a unified view of a direction for future research improvement. It is not realistic to expect to move forward to a new level across the whole broad array of scientific activities in the current local, state or federal research arenas. While the breadth of interests and strengths are a wonderful asset, successful elevation of the Departmental profile will require articulation of a limited number of overarching themes that can capture the attention and enthusiasm of the TAMU Administration, private donors, industry, and federal funding agencies alike. Ancillary benefits should include a more synergistic and dynamic graduate student body, and the sustained support of the considerable alumni ‘power’ (the 12th man!). You need a YELL!
RECOMMENDATIONS

1) Define a new and compelling vision for scientific research and education that is appropriate for a public research university, and capable of positioning the Department among the top-tier peer institutions. Such a vision will involve one or two major crosscutting intellectual themes that have important societal impact. These scientific themes would emerge from areas of traditional strengths, harness the potential synergisms in the Department, College and Campus, and address the key elements of the Vision 2020 for the future.

2) Build on existing scientific visibility and fund-raising potential to provide the resources necessary to enable the transformations that must take place in the next decade in order to fulfill that vision. There is tremendous potential to increase philanthropic support as well as to build strong industrial-associate programs, which provide substantial support. TAMU alumni are justifiably famous for their loyalty and support of the institution, and they represent an important continuing source of practical support.

3) Develop a strategic hiring plan that is compatible with the goals and objectives of the new directions, with emphasis on recruiting bright young faculty, aiding existing faculty develop, and meeting new expectations for entrepreneurial activity and increased level of grant and contract funding.

4) Define, and where appropriate, recruit the transforming individuals (rainmakers) who will lead the intellectual theme areas outlined above. These individuals would be experienced and nationally visible scientists with proven research reputations and demonstrated ability in promoting and organizing large multi-disciplinary science initiatives.

5) Reassess the structure of the graduate program, recognizing the contrasting needs of both professional students and research-oriented students. Professional graduate students represent an important link between the Department and industry, but the quality and quantity of research-oriented M. S. and Ph. D. students will determine the ultimate success of the Department as a research asset of the University. This adjustment will allow the Department to focus its funding on those students who will contribute most to the research enterprise.

6) Take steps to upgrade the overall quality of the graduate students and the graduate program. Critical elements will include (a) a much-more aggressive and targeted recruiting strategy that includes rapid and effective feedback to applicants, (b) much-more-competitive financial packages that leverage Research Assistantships, extend the funding for the full calendar year and recognize research accomplishments, and (c) a substantial reduction in the time required to complete the degree.

7) Any formula-based allocation for setting budgets needs to reflect not only weighted student credit hours but research accomplishments and progress toward the Vision 2020 strategic goals. The formula must provide both incentives and rewards for achieving higher levels of research quality and productivity, and it should allow for special appropriations above and beyond the formula for targeted initiatives. In order to be an effective guide for faculty planning,
both the formula and special appropriations should be clear and readily understandable to the campus community.

8) Develop a long-term plan for the acquisition of state-of-the-art instrumentation and support facilities which are essential for a top-tier geoscience department. A central element of this plan will involve strategic partnerships with other departments, especially within the College of Geosciences, in order to implement a long-range plan for development of shared facilities.

APPENDIX

Sunday 2/24/02

Arrivals

3:39 p.m. Gary Ernst, Stanford University, and Laura Crossey, University of New Mexico, arrive on American Eagle Flight 3793. Bob Popp and Andy Hajash will escort them to the MSC Guest Rooms.

4:37 p.m. Phil Romig, Colorado School of Mines, arrives on Continental Airlines Flight 3676. Bruce Herbert will escort Dr. Romig to the MSC Guest Rooms.

1:15 p.m. Frank Schwartz, Ohio State University, arrives at Houston Intercontinental Airport and will drive to College Station.

Review Team will be housed at the Memorial Student Center (MSC) Guest Rooms on Texas A & M University Campus. Welcome packets containing information, campus maps, and meal tickets will be in Review Team’s rooms upon arrival. To facilitate preparation of the draft report, Room 708 in Rudder Tower will have an IBM Thinkpad laptop computer, printer, and supplies for use by the Review Team. Also the Halbouty Library will be available for use by the Review Team.

6:00 p.m. Andy Hajash and Bob Popp meet Review Team at the front desk of the MSC Guest Rooms and escort them to dinner.

6:30 p.m. Dinner at Christopher’s World Grill (776-2181).
Judith Chester, Rick Gibson, Andrew Hajash, Bruce Herbert, Robert Popp, Anne Raymond

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Monday 2/25/02
7:20 am  Rick Giardino, Dean of Graduate Studies, meets Review Team at front desk of MSC Guest Rooms and escorts them to Provost's Office, 9th Floor, Rudder Tower.
7:30 am  Breakfast, Entry Meeting with Ron Douglas, Executive Vice President and Provost, and Rick Giardino, Dean, Office of Graduate Studies, Rudder Tower, 9th Floor Conference Room.
8:30 am  Bob Popp meets Review Team at Rudder Tower and escorts them to the Eller Oceanography and Meteorology (O & M) Building, Room 204.
9:00 am  Meeting with David Prior, Dean, College of Geosciences, Room 204 Eller O & M Building.
10:15 am Andy Hajash meets Review Team at the Dean’s Office and escorts them to the Michel T. Halbouty Geosciences Building, Room 354.
10:30 am General Department Overview: Andy Hajash, Bob Popp, and Bruce Herbert Room 354.
11:15 am Curriculum Overview: Bob Popp and Bruce Herbert, Room 354.
12:00 p.m. Lunch with graduate students: Catered by Jason's Deli, Room 327, (Bo Slone and others)
1:30 p.m. Meet with faculty: Chester, J., Lamb, Newman, Kronenberg, Spang, Willis, Wiltschko, Room 354.
2:15 p.m. Meet with faculty: Everett, Gangi, Gibson, Hilde, Rabinowitz, Sparks, Room 354.
3:00 p.m. Break
3:15 p.m. Meet with faculty: Ahr, Dorobek, Grossman, Heaney, Raymond, Richardson, Yancey, Willis, Room 354.
4:00 p.m. Industrial Association Programs and collaborative efforts with PETE: Johnson, Watkins, Ikelle, Blasingame, Jensen, Room 354.
4:45 p.m. Return to the MSC Guest Rooms.
5:30 p.m. Reception at the Faculty Club, 11th floor Rudder Tower, West Room.
7:30 p.m. Dinner at Café Eccell (846-7908) with Everett, Ikelle, Johnson, Lamb, Sparks, Zhan

Tuesday 2/26/02
7:00 am  Breakfast MSC Cafeteria – Review Team dine on their own (meal cards for the MSC Cafeteria provided in the welcome packets in hotel room).
8:00 am  Rick Carlson meets Review Team at the MSC front desk and escorts them to the Ocean Drilling Program. Jeff Fox, Director of ODP, will conduct the tour.
8:50 am  Rick Carlson escorts Review Team to the Halbouty Building, Office of the Department Head
9:00 am  Tour of the Michel T. Halbouty Geosciences Building. Chris Mathewson will lead tour with faculty on hand at stops
  Computer Labs, Room 357
  ImmersaDesk Fakespace Lab and future Immersive Imaging Center (Ikelle)
  Computer Teaching Lab, Room 308 (Watkins/Herbert)
  Engineering/Environmental Laboratories (Mathewson, Herbert)
Electron Microprobe (Ray G.)
  Isotope Laboratory (Grossman)
Paleontology Laboratory (Yancey, Raymond)
Center for Tectonophysics (Brann Johnson)
Petrology Laboratory (Lamb)
101 Laboratories
Room 101
11:30 am Tenure and Promotion Committee escorts Review Team to lunch at the Faculty Club, Library Room.
1:20 p.m. Tenure and Promotion Committee escorts Review Team to Halbouty Building, Room 354.
1:30 p.m. Meet with faculty: Giardino, Guillemette, Herbert, Mathewson, Tchakerian, Zhan, Room 354.
2:15 p.m. Meet with Heads of Atmospheric Sciences (Jerry North), Geography (Doug Sherman) and Oceanography (Wilf Gardner), Room 354.
3:00 p.m. Break for Review Team.
3:45 p.m. Special Seminar by Gary Ernst, Halbouty 101, "Subduction of oceanic and continental crust, UHP metamorphism, and tectonic exhumation."
5:00 p.m. Review Team escorted to the MSC by Andy Hajash. Review Team begins preparing their report. Computer equipment and supplies will be available in Room 708 Rudder Tower. Andy Hajash and Bob Popp will be available via phone (see page 1) to answer any questions until 9:00 p.m.
7:00 p.m. Dinner catered by Epicures and delivered to Room 708 Rudder Tower where the Reviewers will be preparing their report.

Wednesday 2/27/02
7:20 a.m. Rick Giardino meets the Review Team at the front desk of the MSC Guest Rooms and escorts them to the 9th floor Conference Room of Rudder Tower.
7:30 a.m. Exit Interview – Review Team meets with Ron Douglas, Rick Giardino and David Prior, Breakfast catered by Food Services.
9:00 a.m. Reviewers check out of the MSC Guest Rooms.
9:15 a.m. Bob Popp meets Review Team with University Vehicle at MSC and transports them (with luggage) to Halbouty Building
9:30 a.m. Informal discussion between Review Team and Executive Committee in Room 354.
10:00 a.m. Review Team presents their report to the faculty, staff, and students in Room 104.
11:30 a.m. Andy Hajash, Bob Popp, and Bruce Herbert take the Review Team to lunch.

Departures
12:45 p.m. Hajash, Popp, and Herbert escort Crossey, Ernst and Romig to Easterwood Airport. Laura Crossey and Gary Ernst depart on American Eagle Flight 3896 at 1:45 p.m. Phillip Romig departs on Continental Airlines Flight 3677 at 2:15 p.m.
1:00 p.m. Frank Schwartz departs for Houston Intercontinental Airport via rental car. Flight leaves Houston 5:33 PM.
Appendix J. Strategic Plan 2005
SUMMARY

The strategic goal of the Department of Geology & Geophysics is to become one of the nation’s premier earth science departments. To achieve that goal, we must elevate not only our research programs, but also our academic undergraduate and graduate programs. For this reason, our strategic plan includes goals and plans for both our academic programs and our research program.

Our undergraduate programs prepare students for technical careers and/or for admission to graduate school, either at Texas A&M or elsewhere. To elevate the undergraduate degree programs, the greatest needs are to attract more majors to the college, to enhance the undergraduate experience, and to offer greater incentives for faculty to invest time and talent in teaching undergraduate students. To meet these needs we will overhaul our Earth Science BS program to attract new majors. We will review and revise our Engineering Geology Option (EGO) to both reflect the growth of environmental geology and prepare students in the Environmental & Engineering Geology Option to qualify for licensure as Professional Geologists. We are actively seeking ways to enhance the undergraduate experience by involving students in research through an undergraduate research experience, an undergraduate thesis, and/or an accelerated MS program. We also propose to modify our tenure, promotion and annual evaluation criteria to make the “scholarship of teaching” a legitimate scholarly activity. To maintain a nationally competitive undergraduate program, it is also important that we maintain our capstone field course; the commitment by the college to provide 1.5 months of salary support for field camp instruction will greatly facilitate this effort. We have asked for and received from Shell additional funds to support the field course.

The strategic goal for our graduate programs is to produce well-prepared and motivated scientists at the MS and PhD levels, who will be competitive for the best positions in industry, government, and academia.

The MS is the entry-level professional degree in geology and geophysics. In keeping with the land grant mission of Texas A&M University, our department has a long history of providing outstanding MS professional degree programs. However, as the nature and aspirations of the university have changed, the emphasis of our graduate programs has necessarily shifted toward basic research. A consequence of this change is that there are fewer incentives and rewards for faculty to engage in the applied research and instruction that are necessary to the health of the MS program. The strategic goal for our MS program is to maintain nationally recognized professional degree programs for students pursuing careers in such areas as hydrogeology, engineering geology, environmental geochemistry, and petroleum geology & geophysics. Two steps we must take to maintain or improve our MS programs are, 1) ensure that MS research is published by requiring that theses be in publishable form at the time of graduation, 2) engage in a Department-wide discussion concerning faculty evaluation criteria for colleagues choosing to promote the professional programs.

In top tier institutions, PhD students are the “engine of research”; a strong PhD program is essential for any department that aspires to national prominence. The strategic goal for the Geology & Geophysics PhD program is to produce PhDs who are sought-after candidates for faculty positions in the best research universities. The key to improving our PhD program is to attract and graduate more PhD students of the highest caliber. To accomplish that, we intend to raise our admission requirements, and substantially elevate our expectations for PhD research quality and productivity by making presentations at national meeting and publication in national/international journals integral parts of the program. To meet our goals for the PhD program there is a critical need for nationally competitive graduate stipends. The recent commitment by the university to pay tuition for GATS has improved our competitive position and opened the door to requesting higher stipends in our grant applications; we have instituted a policy of requesting higher stipends in all grant applications.

In accordance with the recommendations of the PhD Program review Committee, the research goals of the department are to improve research productivity and extramural funding, by becoming national leaders in a few basic areas — the established areas of Petroleum Geology and Geophysics and Tectonophysics (broadly defined),
and the emerging areas of Climate Change, Environmental Geology & Geophysics (under which we include hydrogeology) and Deep Crust and Mantle Dynamics.

Over the last several years our research productivity as measured by rates of publication has reached parity with the nation’s top ten state institutions as measured by the 1995 NRC rankings. However, as also noted by the Review Committee, neither the number and quality of our PhD students nor the number of postdocs in the department is characteristic of a top ten institution. **To improve our overall research performance, we have elevated our expectations for faculty performance (a process we initiated last year), we have instituted a series of research seminars, and we are taking steps to improve the research productivity of our graduate programs, as noted above.**

New faculty hired under ODASES and the Reinvestment Program, and through replacements represent opportunities to make significant improvements in the research productivity and stature of the department. Our overall hiring plan reflects an interlocking set of complementary objectives. Hiring a petroleum geoscientist has the immediate aim of maintaining and improving our petroleum program. Hiring a Geomicrobiologist, an Organic Geochemist, and a Hydrogeologist will strengthen our own environmental geosciences initiative and enhance the college initiative in that area. Similarly, hiring an Open Ocean Paleontologist and a Climate Modeler have the specific aims of enhancing our climate change program and that of the college. An Open Ocean Paleontologist will, and a Climate Modeler could also strengthen our interaction with IODP; we also plan to hire Granular Media Mechanist to work on deformation in accretionary prisms in connection with NanTroSeis, a program of great interest to IODP. The addition of a Geodesist and an Earthquake Source Seismologist to our faculty are specifically designed to help us establish a leadership position in EarthScope.

Our staff requirements and priorities are also shaped largely by our ambitions for the department’s graduate and research programs. Although our administrative staff is sufficient to meet our foreseeable needs, we have two unfilled IT staff positions. **We have a critical need for skilled staff support to update and maintain the department website and to prepare our annual newsletter.** We also have full-time staff support for the electron microprobe laboratory, the Handin Rock Deformation Laboratory, and our burgeoning geochemistry programs. All of these positions are vital to our lofty aspirations – particularly so in light of the immanent expansion of both stable and radiogenic isotope laboratories in the Halbouty Geosciences Building. We recognize that only a fraction of staff salaries can be supported by institutional funds; **additional technical support should be and will be supported by research grants, and by endowment funds raised in cooperation with the college. To support this effort, we have instituted a policy of requesting at least one month of support each year in proposals for research in areas that rely on technical support, as appropriate.**
VISION STATEMENT: STRATEGIC GOALS OF THE DEPARTMENT

The broad strategic goal of the Department of Geology & Geophysics is to make our department one of the best in the country, not just as a research institution, but in the our undergraduate, MS, and PhD degree programs as well. For this reason, our strategic plan is shaped by educational goals for our undergraduate, MS and PhD programs, as well as by our research goals.

Our goal for the educational programs is to prepare our students for admission to the best graduate programs and/or the best and most challenging jobs in academic institutions, industry, and government. We believe that we are well positioned to meet this challenge because of both the size and diversity of our faculty, and because of our long-standing commitment to undergraduate and MS education.

Our goal for research is to achieve national and international prominence by maintaining areas of existing strength in Petroleum Geology & Geophysics and Tectonophysics and by building on and participating in emerging college research initiatives in Environmental Geoscience (particularly environmental geochemistry and engineering geology), Climate Change. Strengths we bring to the Environmental Geoscience initiative are in environmental geochemistry, hydrogeology and engineering geology; our strengths related to Climate Change are in isotope geochemistry and paleontology. Measures we will take to achieve this goal are improving our research productivity and the quality and productivity of our graduate programs, particularly at the PhD level.

CURRENT STATUS OF THE DEPARTMENT

- **Faculty.** The department has a total faculty of 29, including 17 professors, 7 associate professors, and 5 assistant professors. We have several open positions: four reinvestment positions, one or more ODASES positions, and a petroleum geoscientist position. When we are fully staffed under the current plan, we will have 33 or more tenured or tenure track faculty. Professor Hilde has retired. We have used his position to hire Dr. Julie Newman, a structural petrologist. We have also added to our faculty Dr. Brent Miller, a radiogenic isotope specialist, and we have hired Dr. John Hopper to fill our need for a seismic data interpreter. The addition of these three outstanding new faculty members has had an immediate impact on the quality of our department and our research productivity in particular.

- **Staff.** Until recently, the Department of Geology and Geophysics had a total staff of 11, broadly divided into three areas: 4 administrative staff (including 1 administrative assistant, 1 accountant, and 2 secretaries), 1 lab coordinator, and 3 IT staff (two of these positions are currently vacant) and 3 research staff, who support our geochemistry, rock mechanics, and electron microprobe laboratories.

- **Academic Programs.** The department has four undergraduate degree programs, a vigorous MS program, and a PhD program. The four undergraduate programs are BS degrees in Geology and Geophysics, a BA program in Geology and a BS in Earth Sciences. The BS in Geology hosts an Engineering Geology Option. Students can also major in Environmental Geoscience through the Department of Geology & Geophysics. Undergraduate enrollment varies from 100 to 130 students, most of whom are transfers. The graduate program typically has about 100 students, of whom 40% are PhD students and 60% are pursuing MS degrees.

- **Teaching.** The quality of instruction in the Department of Geology & Geophysics is excellent. In 2004 teaching loads ranged from 1 to 10 courses for the full year (including summer sessions); the median formal course teaching load (not including 485, 685, 681 and 691) was 2.5 courses per year, including GEOL 101, GEOL 106, GEOL 307, and several other service courses, such as GEOL 308 and GEOL 320. The introductory courses generate a large number of student credit hours and support for graduate students; during the 12-month period ending 4/30/05, the department enrolled 2400 students in 16 lecture sections and 121 laboratory sections of GEOL 101 and provided 89 semesters of graduate student support. Of 19 lower division lecture sections taught by the department during the '04 -'05 academic year, 17 (89%) were taught by tenure track faculty; the remaining 2 sections were taught by our lab coordinator, Dr. Michael Heaney. Of 45 undergraduate courses taught, 42 (93%) were taught by tenure track faculty, and of 36 graduate courses taught last year, 35 (97%) were taught by tenure track faculty; the electron microprobe course was taught by Dr. Reynald Guillemette, who has faculty credentials.
Research. Our department continues to have strength in studies of the solid earth, our environment, and in the applied fields of petroleum exploration, environmental chemistry and engineering geology. Following a recommendation of a recent external review of our PhD programs to present a more coherent and focused set of research objectives, we have defined four areas of existing or emerging excellence on which we can build for the future: Petroleum Geology and Geophysics, Tectonophysics, Environmental and Engineering Geology, and Climate Change.

The average publication rate over the last three years (’02-'04) is 1.7 papers/year/faculty member; and the average rate of publication in refereed journals is 1.3 papers/year/faculty member. These numbers represent a considerable improvement over the publication rate of 0.5 papers/year/faculty member reported for the Departments of Geology & Geophysics by the National Research Council (NRC) in 1995. These new numbers are comparable to the mean 1995 publication rates at the ten highest-ranked state universities (1.4 papers/year/faculty member).

Though the publication rate has increased substantially, our proposal submission rate is less than 1 per year per faculty member. During 2004, the department had a total 52 funded projects, including IAPs, with total funding in excess of $5M; however, the rate of research expenditures was only ~$1M (~$33k/ faculty member). At present, the department has about $1M in research expenditures per year, and about $2.6M in active NSF/EAR grants as of 7/1/05 (22nd among state institutions). Increasing the level of extramural funding is without question our highest immediate priority; becoming a top tier institution is the most important goal of the department.

National Rankings. The national ranking of the department has improved significantly over the past 10 years. In a recent AGI ranking of the 25 universities that generate 79% of PhDs teaching in American colleges, the department ranks 23rd (in a tie with UT), and in a recent NAPS survey, Geology & Geophysics ranks 21st. As of July 1, 2005, the Department ranked 22nd in Funding from NSF/EAR. These recent rankings, all among the top 25 Geology programs, compare favorably with our 1995 NRC rankings, which ranged from 22nd (Department of Geophysics) to 31st (Department of Geology) to 34th (“geosciences at Texas A&M). New NRC rankings are not expected until 2008.

Peer and Target Institutions. As peer institutions we have chosen Ohio State University, Louisiana State University (because of their petroleum program) and UC Davis (a land grant school with an active geology and geophysics program). These schools occupied the 27th, 32nd and 18th positions, respectively, in the NRC rankings. As a target institution, we have chosen Pennsylvania State University, with whom we have much in common. PSU ranked 4th among state institutions in the NRC study.
STRATEGY FORMULATION

Strengths

The department has several strengths on which to build. Among them are several recognized in the 2002 review of the PhD program:

- Strong graduate and research programs in petroleum geology & geophysics and fruitful connection to the petroleum industry.
- Facilities and equipment that are abundant, available, and reasonably modern.
- Faculty with across-the-board strengths in a wide range of research areas.
- A recognized “pinnacle of excellence” in structural geology and rock mechanics (Tectonophysics), and potential or emerging strengths in Petroleum Geology & Geophysics, Climate Change and Environmental Geosciences (particularly environmental geochemistry).
- A steady upward trajectory in the quality and productivity of the faculty over the last decade.
- Excellent potential for synergism within the college.
- A large number of endowed Professorships and Chairs that can, over time, be used to enhance the faculty.

Other strengths are:

- A high degree of collegiality within the department
- A strong tradition and commitment to undergraduate education, including a unique Engineering Geology Option

Challenges

The PhD review committee also recognized several challenges facing the department:

- Need for a coherent vision to plan future hires, shared laboratory facilities, and fund-raising themes.
- Graduate student capabilities and interests that are incommensurate with those of a top tier research university.
- Need to increase the graduate student applicant pool by raising GAT stipends and gaining extramural funding.
- Need to facilitate a more intense focus and research effort on the part of graduate students.
- Need to raise the overall level of grant and contract support to become competitive with top ten institutions.
- Need to foster research collaboration and crosscutting interdisciplinary programs.
- A shortage of state-of-the-art analytical equipment that results from poor institutional support, low extramural funding and a lack of coordination at the level of the college.

Other, related challenges are:

- A more-or-less steady decline of graduate enrollment since 1990. The need to maintain a large “professional” MS programs in Petroleum Geology/Geophysics, and Environmental/Engineering Geology.
- A heavy commitment to teaching a large number of service courses such as GEOL 101, 106, 307, 308, and 320.

Opportunities

We recognize several potential opportunities to build on existing or emerging strengths of the department:

- Take advantage of the fact that the university now pays tuition for GATs to improve research stipends
- An opportunity to establish a new relationship with the petroleum industry to support the petroleum geology & geophysics program
- An opportunity to use early involvement in SAFOD to build a leadership position in EarthScope
- An opportunity to build on college initiatives in Climate Change and Environmental Geosciences.
• An opportunity to develop unique undergraduate programs that will attract more majors.
• An opportunity to occupy a unique niche in the “Scholarship of Teaching”, which is a well-funded NSF priority.
Threats

Potential threats to the department are:

- The chief threat to the success of our plan is the widespread decline of research support from agencies such as DOE, DOD, USGS, and NSF in traditional areas of geoscience. We may be able to take advantage of increased funding in emerging areas of research such as environmental sciences, nanotechnology, and homeland security.

STRATEGIC PLAN

Undergraduate Programs

Our goal for the undergraduate programs is to graduate students who have the qualifications and tools to be admitted to and to graduate from the best graduate programs. We also seek to enhance the undergraduate experience.

While other departments across the country have reduced the rigor of their undergraduate programs to maintain enrollments, we have continued to offer degree programs with rigorous physical science (chemistry and physics) and math requirements. Nevertheless, our undergraduate programs can be strengthened by improving the communication and math skills of our students, and by enhancing the undergraduate experience by involving undergraduate students in research. Detailed plans have yet to be worked out, but several steps to meet these ends are under consideration, and several steps have already been taken. Among the latter are the following:

- Implementation of the “W” course in the Spring term of 2006 will help to improve writing skills
- Establishment of an “Undergraduate Seminar” to stimulate interest in research
- Establishment of a student resource and study center that is shared by undergraduate and graduate students

New initiatives are:

- Developing strategies for improving math skills, including tutorials, workshops and new instructional strategies
- Establishing an Honors Thesis program and/or a required research project for all undergraduate majors
- Instituting a BS/MS (i.e., an accelerated M.S. degree) program to give qualified students a more direct route to a professional degree
- Updating the Earth Science BS program to attract more majors to the department
- Updating and revising our Engineering Geology Option (EGO) to ensure that students who graduate under the option can be licensed as profession geologists in the state of Texas and elsewhere

We propose to counter the drain upon the traditional geology degree program by introducing new and imaginative undergraduate degree programs. More than 50% of states now require Professional Licensure of Geologists if they practice geology “before the public”. Ours is the only Department in Texas that has the full compliment of faculty, courses and experience to develop an undergraduate degree program that is designed to prepare our graduates to enter the profession with a BS degree or to continue into graduate school for a MS or PhD degree in the “Public Practice of Geology”.

The Department has also proposed a revision of our existing Earth Science degree program, that was originally developed to provide teachers in Earth Science. Recent changes by the Texas Board of Education have removed “Earth Science” from the State’s educational curriculum, resulting in a need to develop a revised degree program that would prepare graduates to teach composite science at the secondary level (Physics, Chemistry, Biology, Geology/Oceanography/Meteorology). In cooperation with the College of Education we have proposed a 5-year Earth Science (Composite Science) degree and Master of Education degree program that will meet a critical need for the State of Texas. A possible variation on the Earth Science (Composite Science) degree program is an Earth
Science/Athletic Department degree plan that will graduate students who could teach science and also coach in secondary education institutions. The Department has also negotiated with the School of Military Science to develop an Earth Science degree program designed to provide both knowledge in Earth systems as they affect military operations and a Commission as an officer in the military forces of the United States.

A chronic problem for undergraduate education at research universities is that, relative to the incentives for faculty to invest in traditional research and outside professional activities, incentives to invest time and effort in undergraduate education are low. That the quality of instruction remains high in our department is a testament to the dedication of our faculty in general, and the junior faculty in particular; a well taught course consumes 15-20% of a faculty member’s overall effort. Moreover, a high priority at the national level (NSF) is integration of research with undergraduate teaching. Ours is a large department. We can afford to invest more effort in our undergraduate programs if we can offer appropriate rewards and incentives for faculty to do so. Moreover, this is a niche in the geoscience research/funding environment that is sparsely populated — an “out of the box” opportunity.

- We propose to modify our traditional Annual Evaluation, Tenure and Promotion criteria to include the Scholarship of Teaching. Extramural funding and publication in suitable journals will be required, but this modification will allow faculty to focus on research in earth science education. Worth noting in this context is that this type of activity has become a high priority at NSF. (This does not mean the abandonment of basic research; the NSF objective is to integrate basic research with education. Prof. Bruce Herbert’s double-edged program is a case in point.)

The capstone course for the Geology Major is the summer field course, GEOL 300. All of the best undergraduate programs in the U.S. offer field courses of at least six weeks duration. Failure to offer our own field course would seriously damage our credibility as a leader in our discipline. Hence, to achieve our aim of improving the academic stature of our department, it is imperative that we continue to offer our field course. The recent commitment of 1.5 months peer annum of salary support for the field camp does much to meet this need. In the meantime we have sought support for the field course from the petroleum industry, and Shell has already made a contribution.

Graduate Programs

The strategic goal for our graduate programs is to produce well-prepared and motivated scientists at the MS and PhD levels, who will be competitive for the best positions in academia, industry, and government.

MS Programs

A specific goal for our MS programs is to maintain nationally recognized graduate professional degree programs at the Master of Science level. The MS is the entry-level professional degree in the earth sciences, particularly in energy exploration and environmental science. This program also trains licensed professional geologists, and prepares our students for challenging PhD programs. Our MS programs in petroleum geology and geophysics have long been a nationally recognized cornerstone of our department, while the demands of protecting, and educating the public about our environment will continue to grow in the coming decade. Consequently, many students come to TAMU to earn professional degrees.

In 2002, the PhD Program Review Committee noted that maintaining a large MS program is an impediment to improving the academic stature of our department. Admittedly, the large number of graduate students seeking “professional” MS degrees is a burden on research productivity, but because of our history and our role in the state as a land grant institution, we cannot reasonably de-emphasize or abandon this program. Our best recourse, therefore, is to take advantage of the opportunities that come with the burden, and make this program one of the nation’s best. The good news is that with rising oil prices, the demand for geoscientists is escalating rapidly; it has been widely reported that there is an urgent need in the petroleum industry for 1300 new geoscientists in the next five years. Because of increasing demand and the fact that our students are held in very high regard, we have witnessed a rapid increase in recruiting. The number of companies who make recruiting trips to our department has risen dramatically over the last two years, and some companies are making visits twice each year.

The new demand for geoscientists has also opened the door to a new relationship with the petroleum industry. In response to that opportunity, we are initiating a new development effort. Our aim is to garner more support for the
department in general, and for the petroleum program in particular. We will begin with the establishment of a new
Advisory Council. That will be followed by a proposal to establish a new relationship with industry partners
consisting of several parts. We will propose the establishment of a “Recruiting Consortium” that will help to
underwrite the cost of a major effort to recruit outstanding students to our graduate program. We will also seek to
obtain more resources for graduate stipends and to support the department infrastructure on which graduate
education depends. Informal discussions with industry representatives suggest that these proposals will receive a
favorable hearing.

Our MS program is in generally good health, but improvements can be made to ensure that it also contributes to the
research goals of the department. Specific objectives are to improve the scientific productivity of the MS thesis and
ensure that MS research is published. To that end, we have implemented the following:

- Requiring a Master of Science thesis in a “publishable” form and expecting submission and publication of
  the research in high visibility refereed journals.
- Altering the Master’s final examination from a “thesis defense” to a true oral examination to provide
  quality control/quality assurance.
- Enforcing adherence to the MS degree schedule.

A significant impediment to maintaining excellence in our professional degree programs is the difficulty of
attracting, rewarding, and retaining faculty who have the requisite skills and practical experience to maintain the
program in a traditional basic research environment. This problem is evidenced by the difficulty we have
experienced in hiring a seismic interpreter and a petroleum geoscientist.

- We are therefore considering a revision of our Annual Evaluation, Tenure and Promotion criteria to
  recognize and reward faculty involved in professional practice activities. While an externally funded
  research program and publication will be required, these criteria will recognize the value of applied (as
  opposed to basic) research and professional practice.

PhD Program

As also noted by the PhD program review committee, an excellent PhD program is essential to the prestige of the
department. PhD students are the true “engines of research” in top tier universities. Our goal for the PhD program is
to develop a dynamic body of PhD students who not only contribute their own publishable research, but who will go
into top positions in the best research universities, government and industry, where they can continue to enhance the
reputation of our department.

A dynamic PhD program requires highly talented and motivated students. To build a culture of excellence among
the PhD students, we have already raised our admission requirements and have begun rewarding high-achieving
graduate students with substantial departmental scholarships. Stiffer recruiting standards may initially lead to a
decrease in the number of PhD students, but experience elsewhere has shown that the numbers are likely to rise as
the reputation of the program improves.

A significant graduate recruitment problem has been that the stipends we are able to offer were not competitive
without tuition remission. Many institutions with whom we compete now offer stipends of $17000 or more plus
tuition remission; we were limited to offering $13000 less tuition and fees amounting to more than $5000. It is little
wonder that most of the best candidates for our PhD program chose to go elsewhere.

We have taken some steps to improve the quality and research productivity of the graduate program:

- We have raised the requirements for admission to our graduate program, and particularly to our PhD
  program. This change is reflected in the fact that prior to 2003 we admitted more than 70% of all
  applicants, while in 2004 and 2005 we admitted 55 and 46%, respectively.
- We also expect and encourage PhD students to participate in national professional meetings.

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• Rewarding high achieving and productive graduate students with substantial scholarships available through the department.

We plan several additional steps to improve the quality and productivity of the PhD program:

• Increasing stipends to competitive levels: over time this will be done for RAs by increasing stipends in proposal budgets; given fixed GAT budgets, increasing stipends for teaching assistants may require increasing teaching loads and employing fewer students.
• Promoting national and international recruiting through enhanced web presence, structuring of research themes, defining curricula for each theme and aggressive recruiting at national meetings.
• Raising expectations of PhD students; requiring two formal presentations to the department; changing the dissertation format to three manuscripts prepared for publication in high profile refereed journals, and requiring a publication in a national or international refereed journal as a condition for completing the degree.

RESEARCH

The strategic goal for our research programs is to achieve national prominence in areas of existing and emerging strength in our department by elevating the research productivity of the department, by strengthening our Petroleum Geology & Geophysics, Tectonophysics programs, by building a leadership position in EarthScope, by strengthening our connection to IODP, and through new initiatives related to Environmental Geoscience, and Climate Change. The key to achieving this objective is to improve the research productivity of the department by improving the research productivity of existing faculty and students and by hiring new faculty in appropriate disciplines.

Improving Research Productivity

As noted above, the average rate of publication in refereed journals has risen to 1.77 journal articles/year/faculty member, a rate of publication that is comparable to the mean 1995 publication rates at the ten highest-ranked state universities (1.4 papers/year/faculty member) as reported by the NRC. While the publication rate has increased substantially, our proposal submission rate is less than 1 per year per faculty member. During 2004, the department had a total 52 funded projects, including IAPs, with total funding in excess of $5M; however, the rate of research expenditures was only ~$1M (~$33k/ faculty member). Increasing our overall research productivity and, in particular, the level of extramural funding is an important goal of the department is particularly important. Beginning last year, we have taken several steps to accomplish this objective by:

• Elevating annual performance criteria and expectations for faculty. Under the revised criteria, faculty members are expected to publish in first rank journals and maintain a funded research program, including an aggressive campaign of proposal submissions. Those who are not positioned to contribute directly to improving the research productivity of the department can contribute by caring a larger share of the teaching, advising and service load.
• Initiating a series of seminars on research opportunities. The purpose of these seminars is to develop more effective proposal strategies, identify funding opportunities and promote new or novel research collaborations.
• Offering in-house proposal reviews by faculty members who have served on review panels for various funding agencies, including NSF, DOD, and USGS. The purpose is to improve the quality of submitted proposals – an essential step in an increasingly competitive funding environment.
• Improving the research productivity of our graduate programs at both the MS and PhD levels (as described above).

The impact of research (as evidenced by citations) and the amount of extramural funding that flows through the department are difficult to forecast, much less control. Two factors we do control are the numbers of papers and proposals submitted; clearly proposals that are not submitted will never be funded. It is therefore essential that we
have a proposal submission rate that is commensurate with our goals. The college has established the expectation that faculty will submit three proposals per year, and the department expects an average publication rate of two papers in refereed journals per year. We have established a research committee to encourage and facilitate the preparation of research proposals. On the other hand, we recognize that the large service teaching load (e.g., GEOL 101, 106, 307, 308 and 320) carried by the department is an inhibiting factor. Most faculty members currently teach at least one service course each year, and a typical course consumes about one day per week. We also recognize that some members of the faculty have a stronger commitment to teaching than to research, and we value their teaching and advising roles. They will be expected to contribute improving our research productivity by carrying heavier teaching and advising loads.

The PhD Review Committee noted that an important factor that limits our productivity and stature is the absence of “rainmakers” among the senior faculty. Endowed professorships and chairs are resources that we can use to this end by rewarding and enabling leadership within the department or hiring outstanding senior faculty as opportunities arise. Consequently, we intend to:

- Make the best use of the Halbouty Visiting Chair to bring high profile visitors to the department.
- Continue to use endowments in innovative ways

The Department has a fundamental obligation to award Chairs, Professorships and Fellowships in ways that move us toward our strategic goals in keeping with the wishes of the donors. In this regard, we ardently disagree with restrictions placed on use of these funds where no restrictions from the donors exist. We trust that we will be allowed to continue to ‘think outside the box’ by using Chair funds in innovative ways, unfettered by arbitrary rules that hinder instead of enhance innovation.

Faculty Hiring Plan

While the graduate program is an essential element of quality research, the expertise and interests of the faculty shape the research program. For that reason we have framed our discussion of hiring replacement faculty in terms of research initiatives.

The hiring plan that has emerged from our discussions is summarized below. Included are planned or on-going searches, as well as replacement positions.

<table>
<thead>
<tr>
<th>Hiring Priorities</th>
<th>Climate Change</th>
<th>Environmental Geoscience</th>
<th>Tectonophysics/EarthScope</th>
<th>Petroleum Geology &amp; Geophysics</th>
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<tbody>
<tr>
<td>Planned or On-going search</td>
<td>Climate Modeler*</td>
<td>Hydrogeologist*</td>
<td>Geodesist *</td>
<td>Petroleum geoscientist**</td>
</tr>
<tr>
<td></td>
<td>MC-ICPMS specialist*</td>
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<tr>
<td>Replacement positions</td>
<td>Open ocean paleontologist</td>
<td>Geomicrobiologist</td>
<td>Quake source physicist 3D seismic interpreter</td>
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<td></td>
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<td>Organic Geochemist</td>
<td>Granular media mechanist</td>
<td>Petroleum systems</td>
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<td>Reservoir modeler</td>
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* Reinvestment position
** Current search to fill existing vacancy

NOTE: We also have an on-going search to fill the ODASES position, which could cover a planned replacement, and thereby open an additional position.

Our hiring plan is based on several criteria: The intersection of commitment (Do we have an established or emerging interest in this area of research?); opportunity for excellence (Do we have a strong enough base of expertise to build excellence in this research area?); and funding opportunity (Is this an area of research that is likely to be supported
by extramural funding?). In the following we consider these criteria in terms of our established an emerging areas of expertise.

**Petroleum Geology & Geophysics**
(Sedimentation & stratigraphy, seismic imaging, seismic interpretation, petroleum systems & petroleum seismology)

Related to one of the state’s principal industries, Petroleum Geology & Geophysics is a vital and traditional strength of the geosciences at Texas A&M University. Most of our students, including those who do their thesis and/or dissertation research in other areas, seek employment in the petroleum industry, and therefore rely heavily on coursework in petroleum geology and geophysics.

The advent of TAMUQ and the Qatar Foundation represent a further potential opportunity. Our strategic plan includes the following specific steps to improve the petroleum program:

- The highest immediate priority is to fill the vacant Petroleum Geoscientist position
- Renew our relationship with the petroleum industry, as outlined above

A significant problem for the Department of Geology & Geophysics is the need for a Petroleum Geoscientist with expertise in subsurface geology to teach petroleum geology and provide linkage between the geological and geophysical elements of the program; a third search to fill this position is currently underway. This search has been hampered by the fact that we were limited to offering the position at the Assistant Professor level, yet the AAPG reports that starting salaries for geologists with 0-2 years of experience are approaching $80,000 per year, far less than the $56,000 average salaries of Assistant Professors in the College of Geoscience. We have a pool of new candidates and we are determined to hire at the senior level this year.

Qatar. The relationship between Texas A&M University and Qatar presents a possibly significant opportunity in this area. Several member of the faculty have attempted to participate or are poised to do so when an RFP is issued or a procedure for submitting unsolicited grant applications is specified. The addition of a Petroleum Systems Specialist and a Reservoir Modeler will probably be needed in the event that research in petroleum geology & geophysics expands.

**Environmental Geoscience**
(Biogeochemistry, Engineering Geology & Hydrogeology)

In our department Environmental Geoscience includes disciplines that relate to human health and safety: environmental chemistry, engineering geology, and hydrogeology. Examples of specific disciplines are high-resolution (near surface) geophysics, subsurface hydrology, contamination, mass wasting mechanics, biogeochemistry, geologic hazards and coastal processes. Faculty associated with this theme have the highest levels of funding and publication in the department, and Environmental Geoscience is a present and future growth area in the geosciences. This theme has obvious links to other programs in the college and the university, including the university-wide graduate program in Water Management and Hydrological Resources.

Future hiring priorities for this working group are an Organic Geochemist and a Geomicrobiologist (which is also a priority for the Climate Change initiative). Environmental chemistry is a well-funded growth area for the department, but is currently limited to inorganic geochemistry; the addition of organic geochemistry and geomicrobiology will make our program uniquely comprehensive. A Geomicrobiologist will also complement the Climate Change program (see below). Another area of interest for our environmental change program is surficial processes.

**IODP**

A priority for the college is building a stronger relationship to and with IODP, and our department is prepared to embrace that effort. IODP has proposed several steps that can be taken to enhance the linkage between IODP and the academic departments. Among then are the establishment of new lab facilities at IODP that can be used for core
analysis in support of research, training and research, using the IODP data base for education, capitalizing on visitors to IODP, and integrating IDOP scientists into the teaching mission of the college.

Unfortunately, our department is not well positioned to participate in these initiatives at this time; we have only one faculty member whose long-term interest and expertise are connected to the drilling program. ODASES was established to address exactly this problem. We look forward to the addition of one or more ODASES faculty to our faculty, and we anticipate offering Dr. Thomas a joint appointment. Moreover, one of the Reinvestment hires and two of the replacement hires we have planned will necessarily have strong connections to the drilling program: the Climate Modeler is likely to depend on ODP/IODP data (indeed, we hope to capture a climate modeler from the ODASES candidate pool.), drill cores are virtually the only source of data for the Open Ocean Paleontologist we have proposed to hire in support of the climate change initiative, and the addition of a Granular Media Mechanist to the faculty has been proposed specifically to study the mechanisms of deformation in accretionary prisms in connection with NanTroSeis, which is a priority of IODP.

Hence, when out hiring plan is carried to completion, we will have four, and possibly more members of our faculty who are directly involved in IODP or depend on data supplied by the drilling program. We note, however, that these hires must be made with care because research funding that derives from direct participation in IODP is not sufficient to build a career. A nationally competitive program in a core discipline is essential to long-term success.
Climate Change
(Climate Change, Global Geochemical Cycles & Paleobiology)

Climate Change is an important research area, not only for the department and the college, but also for the university and the nation. Specific disciplines within the department that are related to this theme are paleontology, paleoecology, stratigraphy, sedimentology, geochemistry and isotope geochemistry. Within the department, the Climate Change group has a high rate of publication and an excellent history of extramural funding. Some specific research topics under investigation at Texas A&M are the role of the carbon cycle in climate change, the role of gas hydrates in climate change, and icehouse-greenhouse and greenhouse-icehouse transitions. NSF has several programs related to climate change, and is the principal source of funds for climate change research. Other contributing agencies are ONR and DOE.

There is an ongoing search for a Low Temperature Geochemist (an MC-ICPMS specialist) and a planned search for a Climate Modeler to support this growing area of scholarship. The top priorities for future hires to support Climate Change research are an Open Ocean Paleontologist and a Geomicrobiologist. An Open Ocean Paleontologist will complement and enable stable and radioisotope studies of global climate change and geochemical cycles, while the influence of microbial activity on the chemical and climatic evolution of the earth is just now being recognized.

Tectonophysics/EarthScope

EarthScope grew from a proposal to drill on the San Andreas Fault (what is now SAFOD), and is the largest program in the history of NSF/EAR. Like ODP and IODP, EarthScope was recommended by the National Science Board and approved specifically by congress. So important is this program that funds are being diverted from other programs in EAR to EarthScope. The program is now in the implementation phase; the operational phase will begin in 2007 and run through 2022 (at least).

EarthScope is a facilities centered program comparable to the Ocean Observatories Initiative. It consists of three components: drilling (SAFOD), a geodetic network (the Plate Boundary Observatory, PBO) and a continental scale seismic array (USArray). The concept/development phase of EarthScope spanned a six-year period from FY98 through FY03, and cost more than $9M. Implementation began in FY03 and will be completed in FY07 at a cost of $197M. Operations began in FY03 with a budget of $400k, but the operations budget will rise to an estimated $24M in FY09. Total funding for EarthScope through FY09 is expected to be $280M. We note, for comparison, that the Ocean Observatories Initiative is a parallel program with a similar funding profile and estimated total expenditures of $274M in FY01-FY12, but a smaller, $10M, steady state budget for operations. According to Herman Zimmerman, Director of NSF/EAR, funding for both geodesy and earthquake seismology research under EarthScope will increase by $2M next year and by $1M per year each for several years thereafter.

Several of the top ten institutions are involved in EarthScope, and it is worth noting that it is mentioned as a target opportunity in the Penn State strategic plan. We have a “ground floor” presence in that Fred and Judi Chester are deeply involved in SAFOD. In addition, IODP is serving as the core repository for SAFOD. Because EarthScope is just beginning, we have an opportunity to capture a leading position in this important national program by participating in all three parts of the EarthScope program. To accomplish that, we have included a Geodesist and an Earthquake Source Seismologist in our hiring plan.

Deep Crust & Mantle Dynamics/EarthScope
(Igneous and metamorphic petrology & geochemistry, marine & global geophysics, mineral & rock physics)

The Deep Crust & Mantle Dynamics working group is a recently recognized existing area of research in our department that draws participants from ODP/IODP and the Department of Oceanography as well as the Department of Geology & Geophysics. Worth noting is the fact that all of the highest-ranked geology and geophysics programs in the U.S. are strong in this area. This group has a broad focus on the physics and chemistry of the crystalline crust and mantle with the objective of understanding the origin, composition, and structure of the crust and mantle, and the processes that affect them. Research in this area is funded largely by NSF, with additional support from DOE, ODP, ARP and industry. Members of the group participate in a variety of programs, including MARGINS and ODP/IODP.
The EarthScope observational facility provides a framework for broad, integrated studies across the Earth sciences. These integrated studies include research on crustal strain transfer, magmatic and hydrous fluids in the crust and mantle, plate boundary processes, large-scale continental deformation, continental structure and evolution, and composition and structure of the deep-Earth. Clearly, studies of the deep crust and mantle will be an integral part of EarthScope, and therefore, we are well positioned to take advantage of opportunities provided by EarthScope.

The lower crust and mantle are, by their nature, largely inaccessible to direct observation. A critical component to a strong mantle/lithosphere program is expertise in characterization of rocks that are available for direct observation through exhumation from depth, and in situ geophysical characterization. Though these positions are not included in the immediate hiring plan, the DCMD group would be strengthened by additional faculty in the following areas:

1. Earth Imaging using seismic or Gravity/EM Methods: Seismic methods: Areas of concentration could include seismic imaging of subducting slabs, partially molten areas, phase transitions, regional to global tomography, or source mechanics. Gravity/EM: Satellite, high-altitude and airborne investigations of regional to global scale geological signatures embedded within Earth’s gravity and magnetic fields.

2. Geochemistry, Petrology, and Mineralogy of Lower Crust and Mantle Rocks. Mineralogy: Experimental investigations of melting, mineral equilibria, phase transitions, and mineral-volatile interactions. Geochemistry/Petrology: Possible areas of concentration include interdisciplinary studies of partial melt deformation, melt transport, melt focusing at oceanic rifts, hot spots and plumes.

STRATEGIC PLAN FOR DEPARTMENT STAFF

Administrative Staff

The department of Geology & Geophysics has only 4 administrative staff: an administrative assistant, an accountant, and two secretaries who serve the needs of nearly 30 faculty and more than 200 students. The primary functions of the secretaries are to support the graduate and undergraduate programs; advising in the department is done entirely by faculty.

IT Staff

Until recently the department has had two computer specialists to maintain the large number and variety of computers that are essential to our educational and research missions. In addition, we have had an information representative whose chief responsibilities were to prepare our annual newsletter (our chief means of communication with former students) and to maintain the department web site. Two of these positions are presently unfilled. We have a critical need to upgrade our website, but at present no capability to accomplish that.

Technical Staff

Our strategic goal for technical staff is simply to have and maintain staff to support the ambitions of our graduate and research programs. The Department of Geology & Geophysics has three staff members who support or manage research facilities including the Electron Microprobe Laboratory, the Handin Rock Deformation Laboratory and our various geochemistry laboratories. Clearly as our capabilities and faculty expand, there will be a need for more technical support for various laboratories. It is also evident that institutional funds are limited; the college therefore mandated a reduction of direct staff support to 25% over the next two years, with the remainder to be supplied from other sources, such as fees, endowments, and research funds.

- One step we have taken is to require that at least one month of staff support be included in budget requests for research that relies on staff support, including IT support beyond routine support.

Electron Microprobe
The Electron Microprobe facility is managed by Dr. Reynald Guillemette. The principal expenses of operating the probe lab are Guillemette’s salary, which is paid from three sources: E&G (75%), IEEF (15%) and Grad Enhancement (10%), and the maintenance contract for the instrument itself ($35,200). The Haynes endowment (which has $72,000 cash available and a book value of $140,000) is intended to support the probe. We have used it very sparingly because we hope it will grow to the point where it will pay for the maintenance contract. Over the last several years, our probe laboratory has operated at an average cost of $92000 per year, with income from use fees of $22000; while our probe is heavily subsidized, at 76% the subsidy is lower than the average. Significantly, research institutions in the U.S. that have microprobe laboratories find it necessary to subsidize them at an average rate of 83%.

It is difficult to estimate the value of the research that is supported by this facility. Since the lab was established in 1990, it has had an average use rate of more than 1200 hours (31 weeks) per year and served the needs of 331 different investigators (including 240 students) from 15 different departments, 4 centers, 1 institute and the Ocean Drilling Program, 16 other academic institutions and 16 corporations and non-profit institutions. In hours the usage breakdown is: 6% for formal courses, 50% Geology & Geophysics research, 12% DOP/IODP research, 4% Oceanography and Geography research. The remaining 32% of probe usage is shared among outside users, and other colleges at Texas A&M University (Engineering, Science, and even Liberal Arts) Users include more than 30 faculty and ~100 students from the College of Geosciences. In addition to his duties as manager of the laboratory, Dr. Guillemette teaches formal courses (GEOL 689) on the use of the probe, and coaches researchers and students in its use. Maintaining the Electron Microprobe is essential to the quality of our graduate and research programs, and to many other programs on campus.

We have developed with the college a plan to support the microprobe facility by increasing fee income, expanding the endowment, and gaining more support from university.

Handin Rock Deformation Laboratory

The rock deformation laboratory is the heart of the Center for Tectonophysics, which has been cited as the department’s “pinnacle of excellence”. There are few, if any, comparable facilities anywhere in the world; over the years, the Handin laboratory has been the site of many seminal experiments in rock mechanics. Today there are 10 faculty members associated with Tectonophysics; the average number of funded projects is 2, with current extramural funding of $1,367,672. During 2001–2004 the Tectonophysics group produced a total of 35 publications (31 in refereed journals) and 78 abstracts; the four experimentalists who rely most heavily on the laboratory have an average of 3 funded projects each, and published 23 papers (19 in refereed journals) and 41 abstracts during 2001-2004. Significantly, this group has published three papers in Nature during the last two years. Tectonophysics currently hosts just 15 students (13 MS and 2 PhD); however, the group competes for prospective graduate students with very prestigious institutions (e.g., Penn State, Brown, UC Berkeley, Stanford and UCLA). In the last two years alone, they have had several truly outstanding prospective PhD students choose to go elsewhere because of our very low graduate stipends.

Since its inception in 1967, the rock deformation laboratory has been supported and maintained by a research specialist. Accounts that support this position at present are E&G (75%), IEEF (10%), Grad Enhancement (5%), and TAMRF (10%). The research specialist assists faculty in the design, construction and operation of high-pressure equipment in the laboratory, and assists in the instruction of graduate students in several courses (GEOL 665, GEOP 615, and GEOP 660). The safe operation of the laboratory is one of the research specialist’s primary responsibilities, and a major concern. Though only a few of our faculty rely directly on the lab, it is an absolutely essential element of Tectonophysics research. Hence, technical support for the Handin Lab is crucial to achieving our lofty ambitions.

With the college, we are working on a plan to maintain the Handin Lab through endowments and other sources of funds.

Geochemistry
The Department of Geology & Geophysics hosts several geochemistry laboratories that support both Environmental Change and Global Change research; the 5 department faculty associated with these programs today have nearly $2,000,000 in current extramural funding, published 21 papers (20 in refereed journals) and 26 abstracts during 2001-2004. The group shares 22 graduate students (11 MS and 11 PhD). The 3 researchers who rely most heavily on chemistry laboratories published 18 papers (16 in refereed journals) and 21 abstracts. These programs are rapidly expanding; the number of laboratories housed in the Halbouty Geosciences Building is scheduled to expand significantly in both number and type. At this point it is important to note that much (indeed most) of the expansion of these facilities will serve faculty from the college, but outside the department.

For many years, and at considerable risk to health and safety of faculty and students, these laboratories were operated without the benefit of technical support. Just last year, we were able to hire a geochemistry research specialist for the first time. The position is currently supported by E&G (75%) and department development funds (25%). His responsibilities include installation and maintenance of laboratory equipment, instruction in laboratory procedures, and, increasingly, safety procedures.

Facilities Management

The PhD Review Committee noted that one of our strengths is the quality of our facilities. Effective management of facilities, including property management, hazardous materials, and fire safety as well as space renovation, is a matter of critical importance, particularly in view of the anticipated expansion and growing complexity of our geochemical laboratories. For several years, Prof. Mathewson has filled this role at a cost of about $27,000 per year. He has done a very effective job; the Halbouty Geosciences Building is in excellent condition, and we have the lowest number of fire and safety code violations on campus. This arrangement has also been cost effective. The commitment by the college to continue this arrangement will help to insure that we can maintain facilities at a level consistent with our ambitions.

IMPLEMENTATION

Several steps have been taken to implement our strategic plan. Among them are:

- Establishment of the student resource area
- Initiation of the Undergraduate Seminar
- A policy requiring the inclusion of support for technical staff in research budgets, as appropriate
- We have begun to realign teaching loads among faculty
- New standards for annual evaluations are in effect for 2005
- Last year we initiated a Research Seminar to assist faculty in identifying research opportunities and preparing competitive proposals

Other steps are pending and will be completed within a year

- A plan to revise the Engineering Geology Option is in committee
- The plan to revise the Earth Science BS degree requirements is pending review and approval by the Dean
- A plan for the accelerated BS/MS program in geology and geophysics is in development
- An aggressive graduate student recruiting program will be in effect next year
- New MS and PhD degree publication requirements will go in to effect as new students enter the department
- We will hire a petroleum geoscientist this year
- We expect to hire two, and possibly four new faculty members under the Reinvestment Plan this year
- We also expect to have one or more ODASES faculty join the department this year

The proof of our success may be expected in three to five years. We anticipate the following

- Doubling or tripling of our extramural funding
• Publications in national journals by all of our PhD students
• A corresponding increase in the number of department publications in national refereed journals
• Vigorous, well funded, and exiting research programs in Climate Change, Environmental Geosciences and EarthScope