THE UNIVERSITY OF OKLAHOMA

ConocoPhillips School of Geology and Geophysics

Mewbourne College of Earth and Energy

EARTH Scientist

2013-2014 Issue

MEWBOURNE COLLEGE OF EARTH & ENERGY
THE UNIVERSITY OF OKLAHOMA

The UNIVERSITY *of* OKLAHOMA
Mewbourne College of Earth and Energy
ConocoPhillips School of Geology and Geophysics
ConocoPhillips

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CPSGG Faculty

CPSGG Alumni

About the Cover:

Students celebrate the opening ceremony of the Bartell Field Camp, located in Canon City, Colo. In 2011. Above: a view of the fire pit and flag pole.

The UNIVERSITY of OKLAHOMA
Mewbourne College of Earth and Energy
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http://geology.ou.edu

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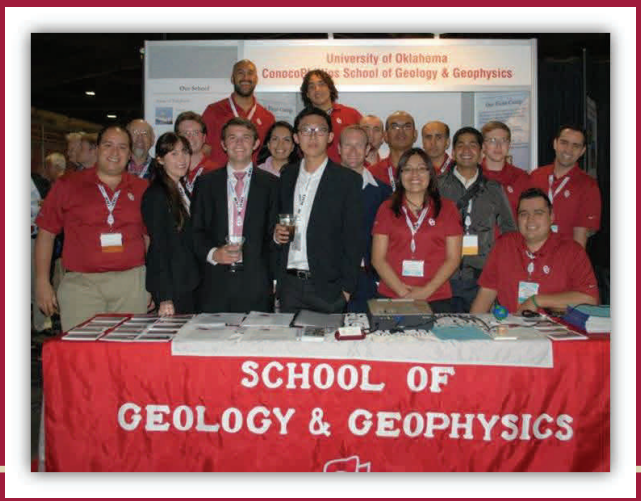


Director's Corner

R. Doug Elmore

The ConocoPhillips School of Geology and Geophysics continued to make progress during the 2012-2013 academic year. Matt Pranter joined the faculty in June of 2013. Short articles on Pranter, petroleum geologist, and Jamie Rich, exploration geophysicist who joined the faculty in fall 2012, are included in this *Earth Scientist*. We are also in the process of searching for two faculty positions. Katie Keranen resigned last summer to accept a position at Cornell University and we are currently searching for her replacement. Additionally, we are searching for a field emphasis assistant professor who will teach field courses and introductory- level courses.

Last summer, field camp went very well. In May, the Alumni Advisory Committee met at the Bartell Field Camp for their annual spring meeting. See the article in this issue of the *Earth Scientist* for an update on all the events at camp in the past year. Our undergraduate enrollments continue to increase. To handle the increased enrollments, David London is teaching mineralogy in both the fall and spring semester. Our graduate enrollments are healthy, with 110 graduate students. We enrolled 40 new students starting in the fall of 2013, which is a record, according to Donna Mullins, academic student services coordinator. Students from more than 30 years ago will remember her — she will be retiring in the next few months. We are currently searching for her replacement. We would welcome any stories form Mullins' early years.

In addition to the courses we teach for our majors, the CPSGG faculty members continue to teach more than 1,500 students in introductory general education courses, as well as courses for the Mewbourne School of Petroleum and Geological Engineering and the Price College of Business. This semester, we are teaching two sections of Introduction to Petroleum Geology and Geophysics for Engineers. We are also teaching five sections of Physical Geology to keep up with the demand from MPGE and other units. Next semester we will teach two sections of Petroleum Geology for energy management majors. Teaching these courses for other units is one of our biggest challenges; how to teach these courses and maintain the quality of our program for our own majors is critical.

OU's Imperial Barrel Team won second place at the annual convention of the American Association of Petroleum Geologists. The team consisted of the following students: William Bailey, Luis Castillo Morales, Alfredo Fernandez, Colleen Klockow and Daniel Sigward, and they were advised by John Pigott, CPSGG professor. OU is now the only school with first-second- and third-place wins in the competition's history.

You will find more detailed information in the state-of-the-school presentation regarding departmental updates and notable events.

Sincerely,

R. Douglas Elmore

R. Douglas Elmore, Director

Letter from the Dean

Larry Grillot

As you will see from this edition of the *Earth Scientist,* the students and faculty in the college are very active and working at a high level. Our students continue to excel, and many have received recognition for their work. Our faculty is providing strong research and teaching, and the *Earth Scientist* highlights the variety of activities in the ConocoPhillips School of Geology and Geophysics as well as both faculty research and student accomplishments.

We continue to see significant interest in the college, with a resulting increase in student enrollment. One of our key areas of current focus is to manage our programs so that we can maintain our goal of providing the best possible educational experience for our students through excellence in teaching, research and creative activity. We value our "hands-on" educational model, which emphasizes laboratories and field work. In this regard, graduate teaching assistants are critical in the effective operation of our labs, and we have received much needed, additional support for GTAs in our G&G programs from the university, alumni and industry during this past year.

The support of our many constituents is key in maintaining our programs at a high level. We truly appreciate the generous support we receive. Please accept my thanks for the support you provide our students. We are excited about the Trailblazer Society, which will provide us with the opportunity to better define the needs of the school and the college, and also to better recognize those who provide such critical support. Please see below for more detailed information.

Thanks again for all you do for the University of Oklahoma, and I hope you enjoy this edition of the *Earth Scientist.*

Stephenson Laboratory dedication. From left: Luis Castillo, graduate student; Tommy "T.D." Craighead, AAC vice chair; Bob Stephenson, OU alumnus; and Doug Elmore, director.

Development Update: Is now your time?

Ameil Shadid

Reflecting back on 2013, it was a good year for us from a fundraising perspective. I am proud of what our "team," including staff members Allison Richardson and Hope Watson, accomplished this year. Our work on behalf of the college and the ConocoPhillips School of Geology and Geophysics provides key support for our students, faculty and programs, which is critical to their success.

Over the past year, we revamped the annual fund solicitation to give you a chance to support both CPSGG and the Mewbourne College of Earth and Energy. You will receive information on how to support the college from Dean Grillot in the spring, then a message from Doug Elmore asking for support of CPSGG in the fall. Your gift makes a difference in the lives of our students by giving the dean and director the chance to invest in field trips, scholarships and student leadership initiatives that provide enriching out of the classroom experiences. Have you made a gift to the annual fund? I hope that you will consider joining our alumni who did make a gift and know that your investment makes a difference.

On Friday, April 4, 2014, we will present the Trailblazer Award to J. Denny Bartell, a 1954 geological engineering graduate. Bartell and his wife, Dixie, who also attended OU, are the third generation of a five-generation OU family. They also are longtime supporters of OU, and their gifts have made a positive impact on many areas of our university. We are looking forward to honoring Bartell's work in the oil and gas industry and as a supporter of OU as a true trailblazer.

The evening also will mark the formal kickoff of our Trailblazer Society, a leadership giving society for our college that gives us a chance to honor and recognize donors for their continued support of MCEE's mission. Alumni and friends who make commitments of $7,500 or more are eligible for membership. Gifts may be directed to a particular purpose, such as scholarships, lab support, or CPSGG or college priorities. Trailblazer Society members also may choose to direct two-thirds of their gift to CPSGG, with the remaining one-third going to support key initiatives at the college level. Members of the Trailblazer Society will be recognized on the Sarkeys Energy Center Trailblazer Society wall and will receive an annual report of how their contributions impacted our students and programs. The college leadership is very excited about this program and, given the reception we have received thus far, our alumni are excited, too!

So, I ask the question again: Is now your time? Is now the time that YOU commit to joining the Trailblazer Society? Or, is now the time that YOU make that first gift to the annual fund?

I would be honored to visit with you about your interest in supporting the college and CPSGG. Please feel free to contact me at (405) 325-0463 or at shadid@ou.edu.

Boomer Sooner!

Alumni Advisory Committee Update

Brad Biddy, Devon Energy (retired)
Chair 2013-2015

Wow! What a year it is setting up to be—baby boomers retiring and opportunities opening up for new graduates to achieve great heights in pursuit of their career objectives. We are seeing a school that is reeling from a drop in state funding, but on display is a resilience based on self-reliance marked by a "can-do" attitude.

After attending the spring meeting of the Alumni Advisory Committee at the Bartell Field Camp in Canon City, Colo., I was blown away by the location, the quality of construction and the overall design of the facility. It was fantastic to renew acquaintances and establish new ones in such a fabulous setting. I cannot say enough about the effort made by our director, Doug Elmore, to make this a world-class location for the teaching of the principles of basic field geology. As I begin my time as chairman of the AAC, I want to recognize the passion Elmore has shown in this effort and to offer him my gratitude.

In my term as chairman, I will put my effort into the following:

-Raising awareness of, and appreciation, for alumni awards, such as the Everett Lee DeGolyer award
-Exploring opportunities for direct alumni involvement in the school (e.g., adjunct professorships and colloquia presentations)
-Encouraging participation in the Trailblazer Society
-Being involved, in any way possible, in helping to provide an educational experience that is second-to-none for geology and geophysics students.

Some of the latest facts about the school and enrollment from the director's state-of-the school presentation at the fall 2013 meeting:

-106 enrolled in graduate program for the fall term 2013 – a new record
- The number of undergraduate students declaring petroleum geology as a major is almost the same level as general geology
-Dedication of two new labs at Sarkeys Energy Center– Noble Energy and Bob Stephenson
-Trailblazer Society Banquet will be April 4, 2014, with our own alumnus Denny Bartell receiving the 2014 Trailblazer Award
-OU Imperial Barrel Team placed first in mid-continent competition and second overall nationally.

I look forward to your participation in these exciting times at the CPSGG. I invite all alumni to contact me with your suggestions – bbiddy@cox.net

Boomer Sooner!

The UNIVERSITY of OKLAHOMA
ConocoPhillips
School of Geology and Geophysics

FACULTY

Geology and Geophysics

R. DOUGLAS ELMORE
Director, ConocoPhillips School of Geology and Geophysics, Eberly Professor and Associate Provost
Paleomagnetism of Sedimentary Rocks, Sedimentology, Diagenesis

MICHAEL H. ENGEL
Professor
Clyde Becker Chair
Organic/Stable Isotope Geochemistry

YOUNANE N. ABOUSLEIMAN
Professor
Larry W. Brummett/ONEOK Chair
Reservoir Characterization, Mechanics of Porous Media

G. RANDY KELLER
Professor
Edward Lamb McCollough Chair
Director, Oklahoma Geological Survey
Geophysics, Structure and Evolution of the Lithosphere from Basins to Upper Mantle, Geoinformatics

ANDREW S. ELWOOD MADDEN
Associate Professor
Low-Temperature, Environmental Geochemistry, Nanoscale Geoscience

DAVID LONDON
Norman R. Gelphman Professor
Experimental Geochemistry, Igneous and Metamorphic Petrology, Geology of Metals, Mineralogy

MEGAN E. ELWOOD MADDEN
Assistant Professor
Stubbeman-Drace Presidential Professor of Geology and Geophysics
Earth and Planetary Geochemistry

RICHARD LUPIA
Associate Professor
Associate Curator of Paleobotany and Micropaleontology, Sam Noble Museum of Natural History
Paleobotany, Palynology, Paleoecology

FACULTY

Geology and Geophysics

KURT J. MARFURT

Professor

Frank and Henrietta Schultz Chair

Seismic Interpretation, Reservoir Characterization, Seismic Processing

MATTHEW J. PRANTER

Professor

Lew and Myra Ward Chair in Reservoir Characterization

Reservoir Characterization and Modeling, Petroleum Geology, Clastic and Carbonate Sedimentology and Stratigraphy

SHANKAR MITRA

Professor

Victor E. Monnett Chair in Energy Resources

Structural Geology, Petroleum Geology, Fractured and Faulted Reservoirs

ZE'EV RECHES

Anadarko Centennial Professor

Structural Geology, Earthquakes, Rock Mechanics

R. PAUL PHILP

George Lynn Cross Research Professor

Joe and Robert Klabzuba Chair

Petroleum and Environmental Geochemistry

JAMIE RICH

Assistant Professor

Exploration Geophysics, Microseismic and Induced Seismicity, Near-surface Geophysics

JOHN D. PIGOTT

Associate Professor

Seismic Stratigraphy and Basin Analysis

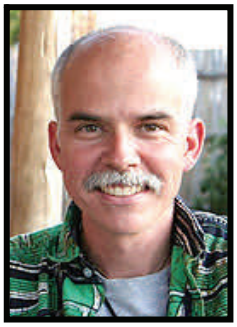
GERILYN S. SOREGHAN

James Roy Maxey Professor

Sedimentology, Stratigraphy, Paleoclimatology

FACULTY

Geology and Geophysics



MICHAEL J. SOREGHAN
Assistant Professor
Sedimentary and Environmental Geology

ROGER M. SLATT
Gungoll Family Chair Professor in Petroleum Geology and Geophysics, Director, Institute of Reservoir Characterization
Reservoir Characterization, Deepwater (Turbidite) Depositional Systems, Unconventional Shales, Clastic Sequence Stratigraphy

BARRY L. WEAVER
Associate Professor
Associate Dean, Mewbourne College of Earth and Energy
Trace Element Geochemistry of Igneous and Metamorphic Rocks

STEVE WESTROP
Willard L. Miller Professor, Curator of Invertebrate Paleontology, Sam Noble Museum of Natural History
Invertebrate Paleontology

EMERITUS FACULTY

JUDSON AHERN
Emeritus Professor
Geomechanics, Gravity and Magnetics, Environmental Geophysics

JAMES FORGOTSON JR.
Emeritus Professor
Petroleum Geology, Basin Analysis

M. CHARLES GILBERT
Emeritus Professor
Igneous and Metamorphic Rock Systems

CHARLES HARPER
Emeritus Professor
Paleontology

DAVID STEARNS
Emeritus Professor
Structural Geology and Tectnophysics

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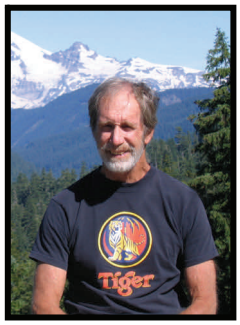
Adjunct Professor
Professor, Department of Zoology
Curator of Vertebrate Paleontology, Sam Noble Oklahoma Museum of Natural History
Vertebrate Paleontology

GAIL HOLLOWAY
Instructor
Courses: The Dynamic Earth, Physical Geology for Science and Engineering Majors, Metamorphic Petrology

GEORGE B. MORGAN VI
Adjunct Professor
Electron Microprobe Operator, Electron Microprobe Lab
Electron Microscopy and Microanalysis, Igneous Petrology, Experimental Geochemistry, Materials Science



NEIL SUNESON
Adjunct Professor
Geologist, Oklahoma Geological Survey
Stratigraphy, Petroleum Geology, Summer Field Camp

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Accounts Specialist

Teresa Hackney
Administrative Assistant

Devon Harr
Special Events and Donor Relations

Stephen Holloway
Research Associate

Nancy Leonard
Financial Administrator

Donna Mullins
Coordinator, Academic Student Services

Wei Wang
Financial Associate

RECENT GRADUATES

Fall 2012, Spring and Summer 2013 Graduates

The UNIVERSITY of OKLAHOMA
Mewbourne College of Earth and Energy
ConocoPhillips School of Geology and Geophysics
ConocoPhillips

BACHELOR OF SCIENCE IN GEOLOGY

Alexander Ahmadian
Musab Almodrra
Emma Baker
Jesse Blumenthal
Caleb Bontempi
Hoang Bui
Charles Crosby
Huong Dang
Jennifer Digiulio
Katherine Foote
Nathan Hasbrook
Scott Hasbrook
Jonathan Hill
John Holcomb
Mallory Irwinksy
Michael Scott Kelley
Brent Klein
Jason Knotts
Brianna Kwasny
Emmanuel Lo
Shawn Maroney
Brooke Morris
Uyen Nguyen
Daniel Parizek
Kavinash Patel
Alexandria Reynolds
Ellen Rosencrans
Ethan Scuth
Jeffrey Westrop
Shelly Wernette
Jordan Williams

BACHELOR OF SCIENCE IN GEOPHYSICS

Saud Al Deghaither
Ali Almahozi
Hussain Alyami
Thang Ha
Hung Nguyen
Khahn Pham

MASTER OF SCIENCE IN GEOLOGY

Daniel Ambuehl
Jean David Amorocho Sanchez
Simon Anzaldua
Alexander Benton
Bryant Bradley
Luis Castillo Morales
Melia Da Silva
Thaddeus Eccles
Justin Haynes
Molly Kane
Edwin "Preston" Kerr
James Maner
Carlos Molinares Blanco
Andrea Serna Bernal
Sezer Sevinc
Ellen Stuchly
Andrew Thiel
Emilio Torres Parada
Henry "Trey" White
Michael Williams

MASTER OF SCIENCE IN GEOPHYSICS

Jon Buening
Guang Chen
Toan Dao
Dustin Dewett
Benjamin Dowdell
Gaurang Patel
Tang Wang

DOCTOR OF PHILOSOPHY IN GEOLOGY

Alsharef Albaghdady
Leslie Keiser
Andrew Swindle

DOCTOR OF PHILOSOPHY IN GEOPHYSICS

Hamed Al-Refaee
Oswaldo Davogustto Cataldo
Roderick Perez
Atish Roy

Larry Grillot, Mewbourne College of Earth and Energy dean, addressing fall 2012 graduates.

Congratulations, graduates!

AAPG Student Chapter

ConocoPhillips School of Geology and Geophysics
The University of Oklahoma

2013-2014 Officers
President: Pierre Karam
Vice President: Rachel Yates
Secretary: Lily Pfeifer
Treasurer: Felipe Cardona

2013 Year-End Report

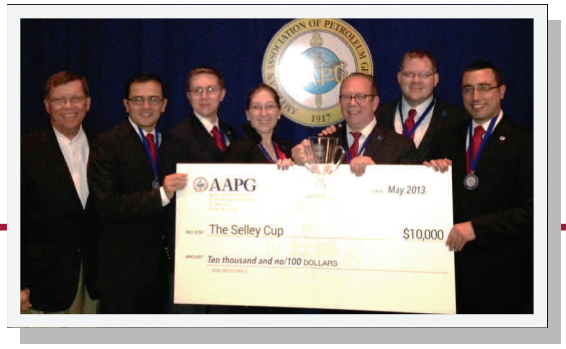
This year, the AAPG student chapter at the University of Oklahoma has organized many beneficial events. These include guest lecturers and short courses, networking and recruiting opportunities, and social gatherings that make it one of the strongest student chapters. Our student chapter currently consists of more than 80 undergraduate and graduate level members that represent a well-diversified population of geologists, geophysicists and petroleum engineers.

Our continued participation in events is molded around our set goals. These goals are: promoting fellowship, stimulating collaboration and sharing knowledge between geoscientist— from students to oil and gas company employees. Through these activities, we afford supplementary opportunities for geology and geophysics students to develop a regard for community, a sense of teamwork, a stronger technical skillset and a larger network base— all essential for success in the petroleum industry.

Last spring semester, we hosted distinguished lecturers from AAPG and SEG, and held a short course taught by Quinn Passey, ExxonMobil geologist, on the geological and petrophysical characterization of organic-rich rocks. The Fourth Annual AAPG/SEG Alumni Kick-off Golf Tournament was a success, as was the AAPG/SEG Spring Break Student Expo. The club supported travel and short course expenses for all students attending and presenting at the various AAPG conferences throughout the year.

Our focus as new officers for this year is to use our funds — from industry support — and bodies — our volunteers — to engineer events that are more centered on community outreach. With the recent natural disasters in Oklahoma, this is a good time for the AAPG students to step up and make a positive impact on the surrounding community. Ideas in progress include visiting elementary schools to impart knowledge to our community's youth, volunteering at a local food bank or tornado-clean up effort, and the creation of an essay competition for a need-based undergraduate scholarship funded by a recent contribution from Shell Oil.

Most recently, John Pigott, OU geology professor, gave a presentation outlining interview tips to be put to use during industry recruiting season. In conjunction with OU's SEG chapter and Pick and Hammer, we hosted our first disc golf tournament and barbecue sponsored by Marathon Oil. A short course will be offered to geology and geophysics students in the fall taught by Mark Sykes, ExxonMobil geologist, on the Monte Carlo Simulation. In the spring, we have scheduled a "lunch and learn" with Joan Eischen, author of *Energy and the City*, who will speak about the path to success as women in the oil industry.



(L-R) Larry Grillot, Luis Castillo, Daniel Sigward, Colleen Klockow, John Pigott, William Bailey, Alfredo Fernandez.

2013 Awards:

Imperial Barrel Competition

First place at AAP Mid-continental Region Meeting

Second place in Annual AAPG Conference

SEG Student Chapter

Society of Exploration Geophysicists
The international society of applied geophysics

ConocoPhillips School of Geology and Geophysics
The University of Oklahoma

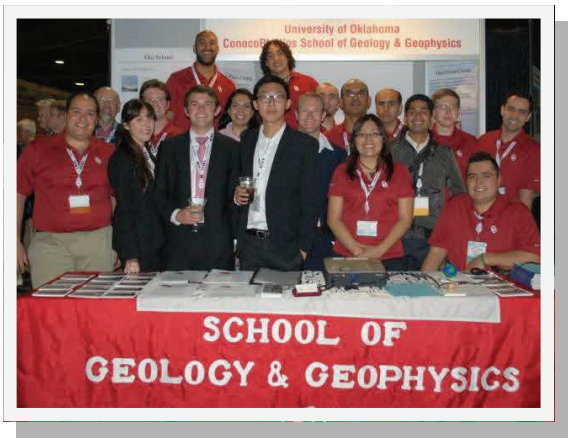
2013 Year-End Report

2013-2014 Officers

President: Tengfei Lin, M.S. Geophysics
Vice President: William Bailey, M.S. Geophysics
Secretary: Shiguang Guo, Ph.D. Geophysics
Treasurer: Sumit Verma, Ph.D. Geophysics

The OU Society of Exploration Geophysicists' student chapter promotes the science of applied geophysics and the education of geophysicists. This year, we have many exciting events taking place that will assist in fulfilling our mission of progressing the field of geophysics, including the SEG Distinguished Lecturer Series, field trips, the SEG Sooner Challenge Bowl, the AAPG/SEG Spring Break Student Expo, presenting at the SEG annual meeting, and social activities, such as the Fifth Annual OU AAPG/SEG Alumni Kickoff Golf Tournament. Through these events, we strive to provide many ways for students to get involved with the school as well as become familiar with many of the oil and gas companies by building a network of industry contacts.

Students at the 2013 OU SEG convention booth.



Students at the 2012 OU SEG convention booth.

We have more than 60 members that include master's and doctoral students from geology, geophysics and petroleum engineering. This diversity allows us to maintain an active presence throughout the college and to promote fluid communication between majors.

This academic year, we are pleased to welcome Nick Moldoveanu, WesternGeco global geophysical adviser, as part of the SEG Distinguished Lecturer Series. This is an incentive that will bring several honored industry professionals to the OU campus to promote geophysics, stimulate general scientific and professional interest, expand technical horizons, and provide a connection to OU SEG student chapter activities and practices.

2012-2013 Events/Awards

Distinguished SEG Lecturer Program

SEG 82nd Annual Meeting

9 poster and 3 oral presentations

SEG 83rd Annual Meeting

10 poster and 9 oral presentations

SEG Sooner Challenge Bowl

10th Annual AAPG/SEG Spring Break Student Expo

446 students, 59 posters and 21 company sponsors

Fifth Annual AAPG/SEG Kick-off Tournament

More than 15 participants paired with industry representatives

Pick and Hammer

ConocoPhillips School of Geology and Geophysics
The University of Oklahoma

2013 Year-End Report

Pick and Hammer is off to another amazing start this year, thanks to a new group of energetic and exciting officers. During the last academic year, Andrew Swindle, past president, was in charge of the newly founded outreach program. At that time, we did not have an officer position to handle the additional load of responsibility and work. Because of the marvelous success the outreach program has seen, we added an officer position to handle the coordination of these events. Amy Bailey was elected to be our public outreach officer and continues to do a great job. We have started a program and send club members to third-grade classrooms in the community to educate about geology. Beyond the third graders, we also work with middle school students during their Science Olympiad training. One of those schools went to the regional and state level competition. In years to come, we hope to expand into high school classrooms to speak about the rigors and importance of course work toward achieving your goals.

In the fall of 2013, Col. and Mrs. Donald Bye donated their daughter's rock and mineral collection. Bethany Ann Nauman passed away leaving behind memories, such as this rock and mineral collection. The collection, which will be hereafter called the "Bethany Ann Nauman Collection", will be used in the public outreach program. It will be kept at Sarkeys Energy Center and taken to public schools where third grade students and Science Olympiad students will use them to understand mineralogy and geology. On behalf of the officers and members of Pick and Hammer, we would like to thank the Byes for donating the collection to the club.

Continuing into the 2013-2014 school year, we have been able to maintain a successful record of great field trips. Ten club members traveled to Wheeler Peak, N.M., elevation 13,167 feet, to sample porphyritic quartz, feldspar rhyolite and hornblende gneiss. Our treasurer, Rebecca Funderburg, led a trip to the Salt Plains of Oklahoma, where club members collected selenite crystals. More trips and events planned for fall 2013 include a day of hiking and climbing at Quartz Mountain, Okla., and a bonfire at Lake Thunderbird.

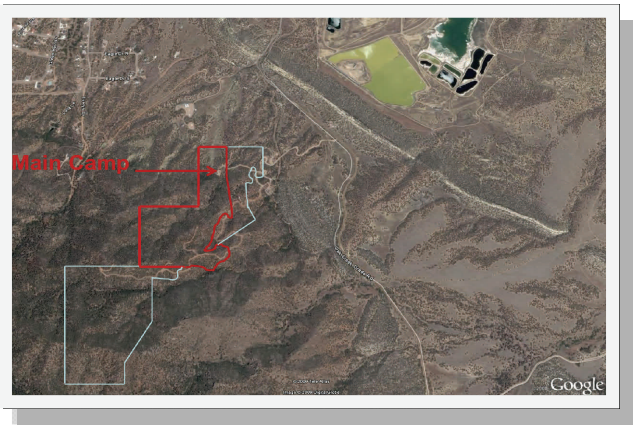
One of the events that Pick and Hammer members get excited about is the annual mineral auction at the Trailblazer Award Ceremony. Last year, we brought in more than $5,000 that will sponsor club activities. Philanthropic work is a top priority for our club. We were able to fund the travel expenses for 30 members to the 125th anniversary of the Geological Society of America conference in Denver. Closer to home – we were able to make a donation to former Pick and Hammer officer, Jamie Miller, who lost her home in the Moore tornado.

Pick and Hammer is still designed to be a social club for geology students. We are proud to say that our club members are as excited to work with the public school system as they are to enjoy a bonfire at Lake Thunderbird. Thanks to the alumni for all of the support of our ever-growing club.

Bartell Field Camp Update

R. Doug Elmore

All of the buildings at Bartell Field Camp were completed in summer 2013, including the two new larger faculty cabins with three rooms and the high camp gazebo. We also purchased new land around the camp – 143 acres for $50,300. The newly acquired land includes a garage, which was much needed for storage. Some of you may recall that there was a fire at Royal Gorge near Canon City, Colo., last summer. Our students and the camp were never in danger, although we watched the situation very carefully. I also noticed that there were a number of dead trees in and around the camp last summer, causing a potential fire hazard, and we are having the trees removed for safety reasons.



The red outline indicates the original land purchase. The white outline is the newly acquired 143 acres.

The new gazebo after installation at high camp.

The two new faculty cabins located across the gulley near the main road.

The newly acquired garage.

Last summer, 13 of our students attended geology camp, and we recruited 17 students from other schools. Tuition from outside students helped to cover the costs of running the camp. We did not offer the geophysics capstone course because there were not enough students; Jamie Rich will offer the course in the summer of 2014.

We continue to encourage other units to use the camp for retreats. The financial managers at OU had a very successful retreat in September of 2013. Faculty and staff also have stayed at the camp for a very reasonable fee, and alumni also are welcome to visit and stay at the camp.

Doug Elmore takes alumni on a trip to high camp during the spring AAC meeting.

The spring AAC meeting also was held at the camp last May.

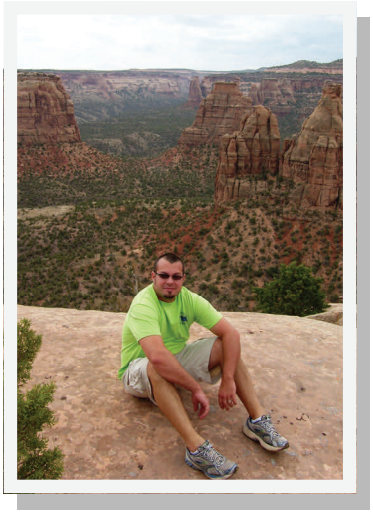
We awarded more than $37,600 in scholarships to 13 of our students who attended camp last summer. We paid the entire field camp fee of $1,800 for our students, and those students with GPAs greater than 3.0 received additional funds. Scholarship funds were provided by the Geophysical Society of Tulsa; John Doughtie, alumnus; the Oklahoma City Geological Society; the Oklahoma Geology Foundation; and the ConocoPhillips fund.

We are continuing to receive donations from generous alumni and corporate sponsors. The Terry and Christina Axtmann Field Camp Fellowship has begun establishment by Terry and Christina Axtmann. Terry received his master's degree in geology from OU in 1983. The Axtmanns believe in the importance of field work, and this fund will provide support for CPSGG graduate teaching assistants at the field camp. We also have many more thoughtful gifts from alumni (Ken Nelson, Bill and Virginia Dunn, Dub Peace, Robert Womack, David Bryant, Peter Blau, Aaron Liesch, Paul Mershon, J. Robert Luke, Harry Spooner, Joseph Meinert, Jerry Medina, John Kinard and others). We also received matching gifts from ExxonMobil and Chevron. All gifts are much appreciated by the school.

For the second time, I took the students on a one-week trip to the Mississippi Delta at the beginning of camp to study modern deltaic sediments. Trip expenses are covered by a generous donation from Chevron. We stayed at the Louisiana Universities Marine Consortium in Cocodrie, La., and studied the marsh sediments as well as a visited the barrier islands. The students took cores in the marsh and on a barrier island. They compared the modern sediments with the ancient rocks they saw in the Canon City area, and then wrote a paper while at the Bartell camp comparing them. We also visited a swamp and spend part of a day in New Orleans visiting the levees and other geologic features.

Youngblood Energy Library Update

Jeffrey Widener, a broadly trained cultural and environmental geographer with professional experience in geographic information systems and urban planning, has been named as University of Oklahoma Libraries' first geospatial information systems librarian. In this newly created position, Widener will lead OU Libraries in the development of geospatial data services, programs and collections. He brings experience in utilizing geospatial data as well as teaching geo-techniques and other geography-related courses.



"As OU's first GIS librarian, I look forward to working with students and colleagues across campus and helping them use these new resources," Widener said.

Rick Luce, dean of University Libraries, said, "Widener has the unique ability to both "speak the language" of GIS and apply that across multiple fields, and to teach others to use geospatial tools and data sets to empower their research. This combination of skill sets makes him a great asset to OU libraries."

GIS (geographic information systems) and GPS (global positioning systems) have become extraordinarily important in today's interconnected world. From GPS-enabled smart phones and cameras to geo-tagged "tweets," smart grid management, and U.S. security efforts, GIS and GPS have become part of everyday life.

Geospatial data involves more than electronic mapping resources, however. It exists as well in archives – in oral histories, maps, texts, art and photography. Widener anticipates developing a GIS archival program using Open Source data that will assist the OU community and serve as a resource for others.

"Jeff brings experience teaching university-level GIS and geography courses as well as practical GIS experience in city government," said Jody Foote, the geology librarian in the Youngblood Energy Library. "A published author and member of several GIS and geography professional organizations, Jeff has a passion for geography and teaching geospatial information skills that gives him a strong foundation for

This rock cluster is a new addition to the Youngblood Energy Library in Sarkeys Energy Center. The cluster of barite roses, from Noble, Okla., was dug with hand tools in 1994 by David London, geology and geophysics professor. It was donated to the library by longtime donor Mrs. Laurence S. Youngblood. The display was fixated in spring 2013.

Meet the new faculty...

Jamie Rich

Assistant Professor

Jamie Rich joined the ConocoPhillips School of Geology and Geophysics in the fall of 2012 as an assistant professor in geophysics. Prior to joining the university, he spent six years working for Devon Energy, most recently as a senior geophysicist. While at Devon Energy, he worked in a number of North American plays, including the Barnett Shale, Granite Wash and Permian Basin. He spent time both as an interpreter within various business units as well as part of Devon's geophysical technology group.

Rich enjoyed a number of teaching opportunities before joining the faculty full-time at OU. At Oklahoma State University, he taught seismic interpretation each spring semester from 2008-2012. He first taught seismic exploration at OU during the fall 2011 semester as an adjunct lecturer and has continued each fall. A core geophysics course, it introduces upper-division undergraduate and beginning graduate students to exploration seismology, including wave theory, acquisition, processing and interpretation. During spring 2013, Rich taught a well-received course on geophysics for unconventional plays and anticipates continuing that course in the future.

A Pennsylvania native, Rich grew up in what is now the heart of the Marcellus shale play. He received his undergraduate degree in applied physics with a geology concentration and a second major in anthropology from Indiana University of Pennsylvania. He also participated in various archaeological research projects while at IUP. His decision to pursue geophysics was based on the ability to combine his passions for physics, geology and archaeology. Rich first moved to Oklahoma and joined the university as a graduate student in the summer of 2001. He completed his master's degree working with the late Alan Witten, OU professor, using diffraction tomography to image buried waste at Idaho National Lab using shallow seismic reflection and offset vertical seismic profiling. During his master's program, he also completed an internship at Lawrence Livermore National Lab, where he developed an algorithm for imaging with ground-penetrating data. After completing his first OU degree, he began his doctoral research with Witten working on a Hilbert space inverse wave imaging algorithm for electromagnetic induction data in heterogeneous backgrounds. After the untimely loss of the beloved Witten, he completed his studies under professor Evgeny Chesnekov, investigating both elastic and electromagnetic wave propagation in layered, fractured media.

Rich's current research interests include microseismic monitoring, characterization of anisotropic wave propagation and ground-penetrating radar for shallow applications. He is actively participating in various consortia in the school, including the Attribute Assisted Seismic Processing and Interpretation and the Granite Wash and Mississippian Lime consortia. He has helped organize various workshops related to unconventional resources, passive seismic monitoring and induced seismicity. His current professional roles include guest associate editor for a special topic on microseismic monitoring in the journal *Interpretation* and associate editor for passive seismic for the journal *Geophysics*. He is a member of the Society of Exploration Geophysicists, Society of Petroleum Engineers, the European Association of Geoscientists and Engineers and the National Association of Geoscience Teachers.

Meet the new faculty...

Matthew J. Pranter

Professor, Lew and Myra Chair in Reservoir Characterization

In June of 2013, Matt Pranter joined the ConocoPhillips School of Geology and Geophysics as professor of geology and geophysics and the Lew and Myra Ward Chair in Reservoir Characterization. His research and teaching interests are in reservoir geology and geophysics, sedimentology and stratigraphy, and 3-D reservoir modeling, and he directs the Reservoir Characterization and Modeling Laboratory within the CPSGG. Prior to joining OU, Pranter was a petroleum geology professor at the University of Colorado at Boulder for 12 years and also worked in industry with ExxonMobil Upstream Research Company and Conoco. Pranter holds undergraduate degrees in geology and geological engineering from Oklahoma State University and Colorado School of Mines, respectively, his master's degree in geology from Baylor University and his doctoral degree in geology from Colorado School of Mines. He is originally from Oklahoma City and is glad to be close to family members in Oklahoma.

Pranter has more than 22 years of experience in sedimentary and petroleum geology, and his research crosses the boundary between "fundamental" and "applied" research. He and his students focus on questions that address how characteristics of sedimentary rocks (*and processes that form them*) impact heterogeneity at different scales in reservoirs. This multidisciplinary research involves the "field scale" analyses of depositional systems, stratigraphic architecture and sedimentology as applied to petroleum reservoir geology and geophysics. His current research has investigated the stratigraphic variability of fluvial deposits and their associated connectivity, with a focus on Cretaceous formations in the Rocky Mountain region. During the past 10 years, he has directed the Williams Fork Consortium for outcrop- and subsurface-based research on fluvial deposits and reservoirs in the Piceance and Uinta basins with funding from industry, the Research Partnership to Secure Energy for America and the American Chemical Society – Petroleum Research Fund. He and his students also have evaluated the elemental chemostratigraphy and organic richness of the Niobrara Formation in the Piceance Basin. Most recently, at OU, he has initiated research consortia on the "Granite Wash" of the Anadarko Basin, the "Mississippi Lime" of the midcontinent and continues his research in the Rocky Mountain basins.

Pranter teaches at both the undergraduate and graduate levels at OU. This fall, he instructed the senior-level petroleum geology course for our geology and geophysics majors and co-instructed (with Kurt Marfurt) Introductory Petroleum Geology and Geophysics for the petroleum engineering undergraduate majors. He will co-instruct (with Roger Slatt) the graduate-level 3-D reservoir modeling course , Reservoir Characterization II, and a seminar course on reservoir characterization in spring 2014.

Pranter is a member of AAPG, SEPM, SEG, GSA, EAGE, OCGS and RMAG. He has been a session co-chair, short-course instructor, and field-trip leader at AAPG/SEPM annual conventions. He serves as associate editor of the *AAPG Bulletin*, a reviewer for several peer-reviewed journals and has previously served on several AAPG committees.

State of the School

As presented to the Alumni Advisory Council on Nov. 9 by R. Doug Elmore, Director

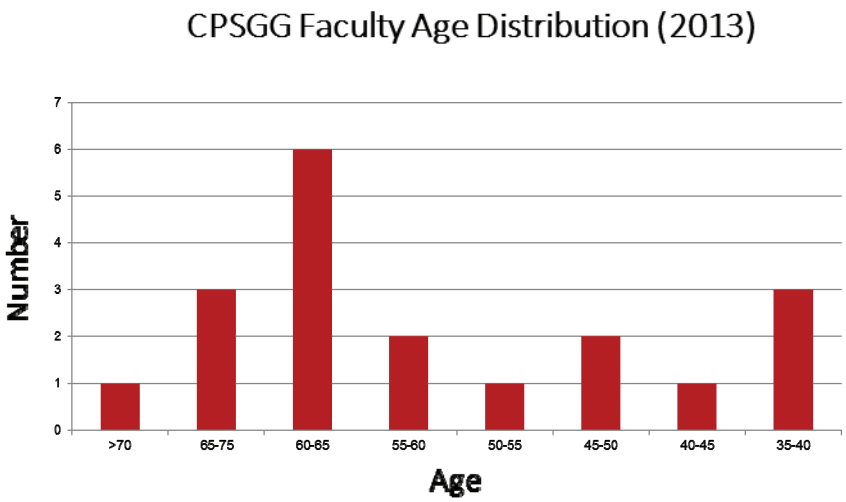
Faculty

- 11 full-time tenured faculty

- Andy and Megan Elwood Madden granted tenure and promoted to associate professors

- One tenure-track assistant professor (Jamie Rich) and one ranked-renewable term assistant professor (Mike Soreghan)

- Advertising for two positions: 1) solid earth geophysics and 2) field emphasis and teaching intensive ranked-renewable term



Challenge: Ten faculty are eligible to retire in six years.

Teaching

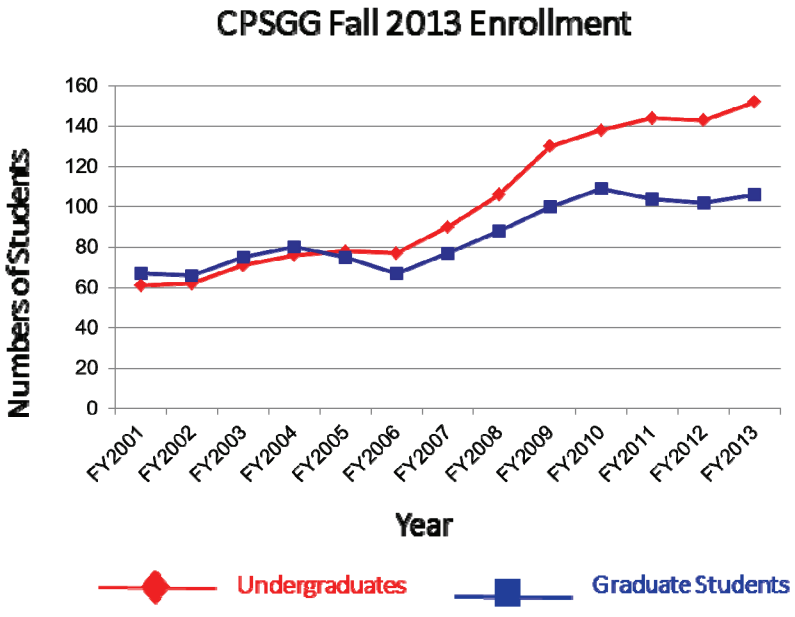
- 152 undergraduates, plus additional undeclared majors currently in University College

- 106 graduate students; 40 new students this fall

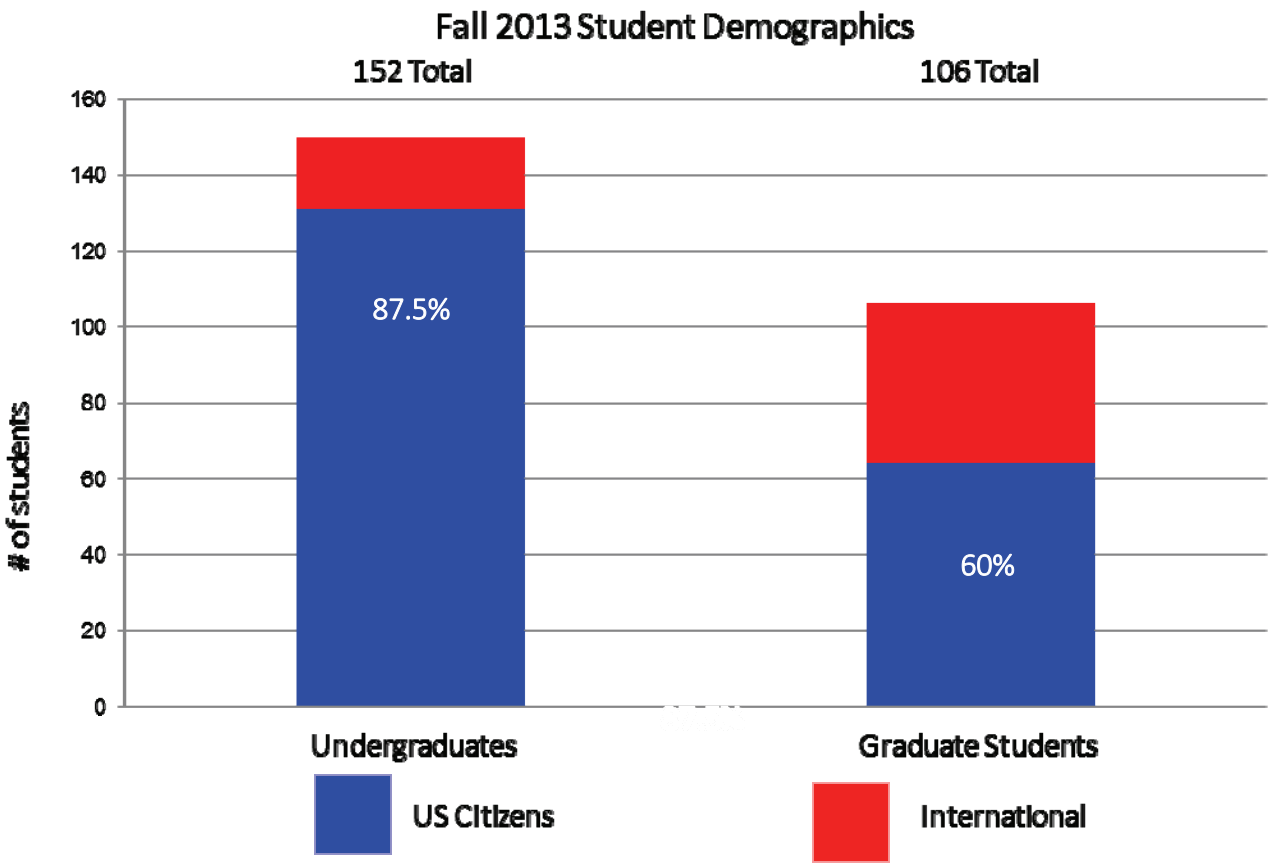
- Faculty taught four courses per year in 2012-2013 with more than 400 credit hours per year

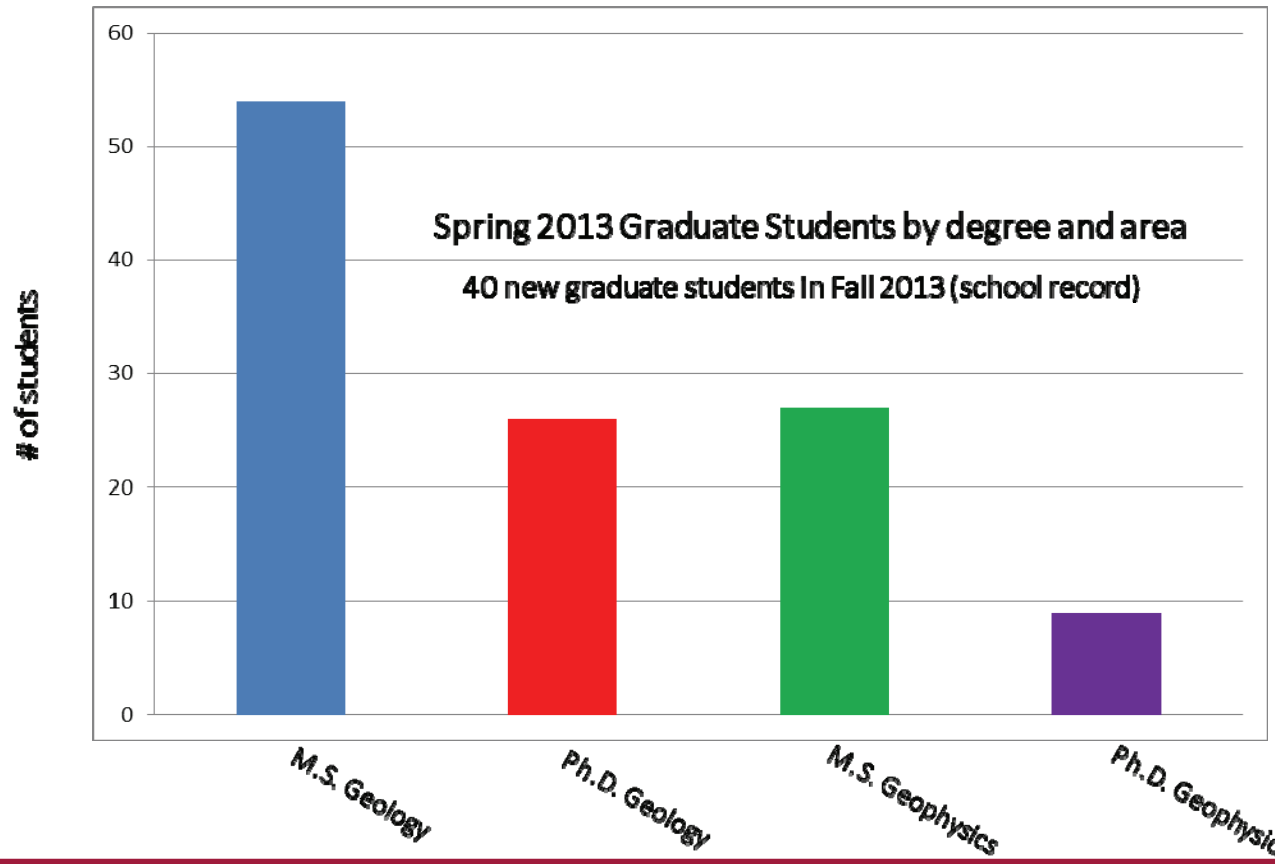
- Enrollment increases in MPGE, energy management and CPSGG created a heavy course-load for our program

- Considering restructuring GEOL 1114 and are soliciting adjuncts for assistance in teaching

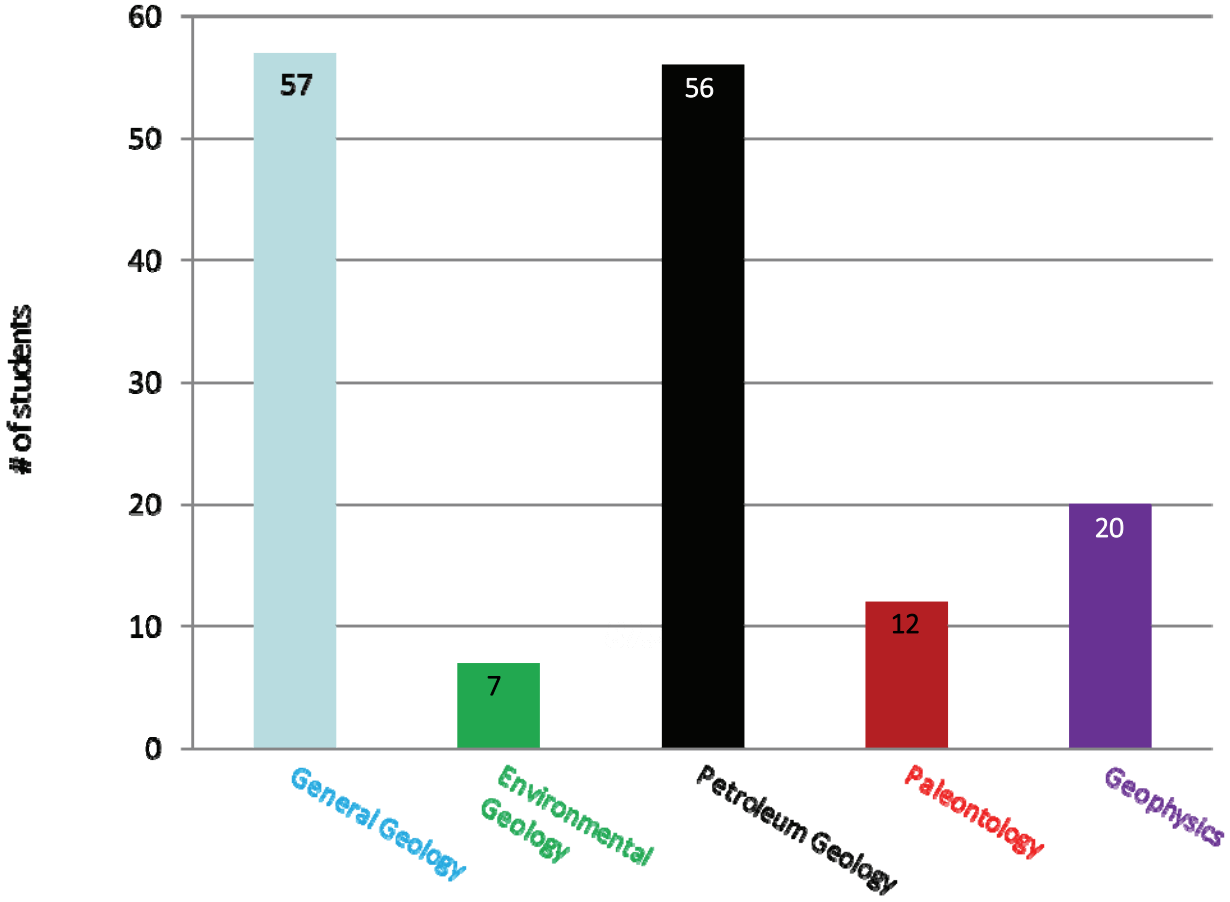


Challenge: How to teach these courses and maintain the quality of our program.

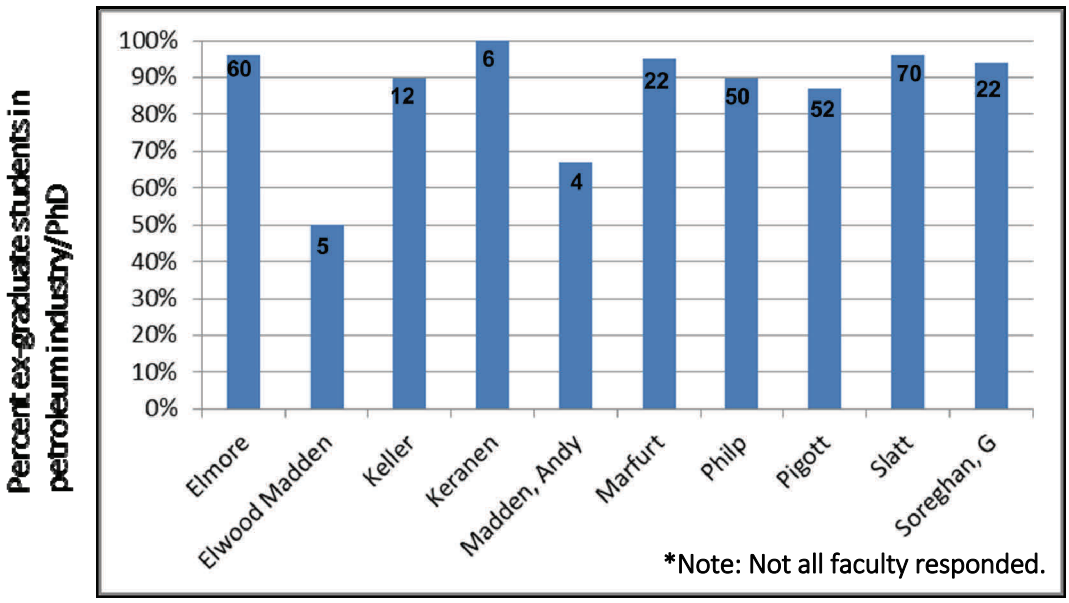

Fall 2013 Student Demographics
152 Total
106 Total
160
140
120
100
80
60
40
20
0
# of students
87.5%
60%
Undergraduates
Graduate Students
US Citizens
International


60
50
40
30
20
10
0
# of students
Spring 2013 Graduate Students by degree and area
40 new graduate students In Fall 2013 (school record)
M.S. Geology
Ph.D. Geology
M.S. Geophysics
Ph.D. Geophysics

Fall 2013 Undergraduates by major area



Percent ex-graduate students working in the petroleum industry



Notable Events:

-At our spring picnic and honors event, Uyen Thi Thanh Nguyen received the Charles N. Gould Award. Ellen Marie Rosencrans received the David W. Stearns Awards; Khanh Le Huy Pham and Thang Nguyen Ha received the Alan Witten Award; and Jennifer P. DiGiulio received the Estwing Hammer award. The staff awarded the Student Rock Award to Richard Brito and Sumit Verma. Shannon Dulin received the Stan Cunningham Outstanding Teaching Assistant Award. Carlos Molinares received the Ben Hare Award for Research. Andrew Swindle was awarded the DeGolyer Scholarship and Tyler Foster received the Outstanding Student Award from the Tulsa Geological Society. Bryan Turner and James Maner received the Rocky Mountain Gem Club Scholarship.

-Megan Elwood Madden was awarded the Stubbeman-Drace Presidential Professor of Geology and Geophysics.

-This fall, 27 companies interviewed on campus, and our students continue to get jobs. The AAPG/SEG Spring Break Student Expo event was successful, with more than 300 students from around the country participating. That's almost double the participants than last year. Brandon Lutz (University of Alabama) and Gabriel Machado (OU) won first place at the regional SEG Challenge Bowl competition.

-We continue to have many field trips in our courses, including the freshman field trip, as well as trips to Galveston, the Permian Reef of west Texas, Arkansas, the Florida Keys, Death Valley and the Barringer Crater. These trips are expensive, and we appreciate the support provided by alumni and company sponsors.

-This past year, two rooms were dedicated to the enhancement of the Institute of Reservoir Characterization within the CPSGG. Both of these dedications were made in recognition of the contributions to education, both teaching and research, made by this institute under the direction of Roger Slatt. The first of the two dedications was named the Noble Energy Company Reservoir Characterization Center Laboratory, and is located in the basement level (Room N102) of Sarkeys Energy Center. The second of the two dedications was named the Robert L. and Norma E. Stephenson Geologic Reservoir Characterization Core Facility, and is located in the basement level (Room B102) of SEC. Plaques in honor of Noble Energy Co. and the Stephenson family have been placed at the entrance to both facilities.

-The Pick and Hammer students have started great outreach opportunities for local schools. See the article in this issue for more details.

-We are also doing an electronic newsletter three times a year with more current information about our school than can be provided in the *Earth Scientist*. If you know someone that would be interested in receiving the newsletter or annual magazine, please contact Devon Harr at devonharr@ou.edu or (405) 325-3253.

Faculty/Student Articles

The UNIVERSITY of OKLAHOMA

ConocoPhillips

School of Geology and Geophysics

Characterizing a fault-zone and associated fractures using lab experiments and attribute-based seismic analysis: an example from Woodford Shale, Anadarko basin, Oklahoma

Zonghu Liao, Nabanita Gupta, Ze'ev Reches and Kurt J. Marfurt

The Woodford Shale exhibits complex geophysical features (e.g., sub-seismic fractures) that are critical for gas exploration. Seismic attributes are effective tools in characterizing the patterns of discontinuities within shale reservoirs. In this study, we characterize a fault/fracture system within the Woodford Shale by integrating seismic attributes analyses and laboratory scale modeling to better interpret of this system. The area of interest covers an area of 360 mi^2 at the Woodford Shale level in central-west of Oklahoma with 3-D seismic provided by CPSGG. We focused on a 20-mile-long, north-south fault that is interpreted as a strike slip fault.

The clay experiments described the associated structures of a strike slip fault, suggesting the development of Riedel shears, splay shears and P shears. These secondary faults and the geometries of the surface horizon are understood as common features for strike slip faults and are used as proxies to identify the fault nature in 3-D seismic volume. We applied three attributes (coherence, dip-azimuth and curvature) to illuminate the fault and we observed the Riedel shears, splay shears and P shears through coherence.

Chopra and Marfurt (2007) define coherence as the energy of the coherent part of seismic traces divided by the average acoustic energy of input seismic traces which could be used to identify lateral discontinuities (e.g., faults) in the 3-D seismic data. Figure 1 shows the rendered coherence attribute of the study area. The major Riedel shear faults are colored as black, while green indicates splay shear faults. Also, P shears are indicated by red lines connecting Riedel shears. By comparison between the clay modeling and coherence attribute map, we think it is qualitative to confirm the major features of strike slip fault. Additionally, it has planar horizon and small vertical offset with discontinuity across the fault (connected green points), so we interpret this north-south fault as a strike slip fault.

We next explored the dip-azimuth distribution along the north-south strike fault. The dip-azimuth is perpendicular to the geologic strike and is measured in the direction of maximum downward dip. (Chopra and Marfurt, 2007). The pattern of (Fig. 2) yellow-green bands from northeast to southwest is orientated similar to that of Riedel shears with respect to the main strike-slip fault in the clay model. We interpret the pink-red bands as likely P-shear zones of fractures. The aforementioned fault perpendicular to this north-south strike slip fault is interpreted as normal fault referring to the pink zones of dip-azimuth angle and also the incoherence along this fault (Fig. 1b).

Curvature values were extracted and rendered to the horizon slice (Fig. 3) along the fault, including most-positive and most-negative curvatures. Most-positive and most-negative curvatures are popular attributes to exhibit anticlinal and synclinal components of folds, respectively. The most interesting finding is the curvature map further shows the pattern as a combination of the secondary fault and associated folds which records the movements of the fault blocks with respect

to each other. The red color shows bands of most positive curvature, which indicates the compressed folds, and the blue color shows the syncline folds. The anticlinal (compressed) folds are usually correlated with high intensity of natural fractures (Sterns, 1978; Guo et al., 2010; Staples, 2011). Thus, the fold zones with high positive curvature values probably reflect the choice for horizontal drilling in this case.

For more details, please see the following reference in the SEG expanded abstracts:

Liao, Z., N. Gupta, Z. Reches, and K. J. Marfurt (2013), Characterizing a fault-zone and associated fractures using lab experiments and attribute-based seismic analysis: an example from Woodford Shale, Anadarko basin, Oklahoma, SEG 2013 (Houston) Expanded Abstract.

Figures:

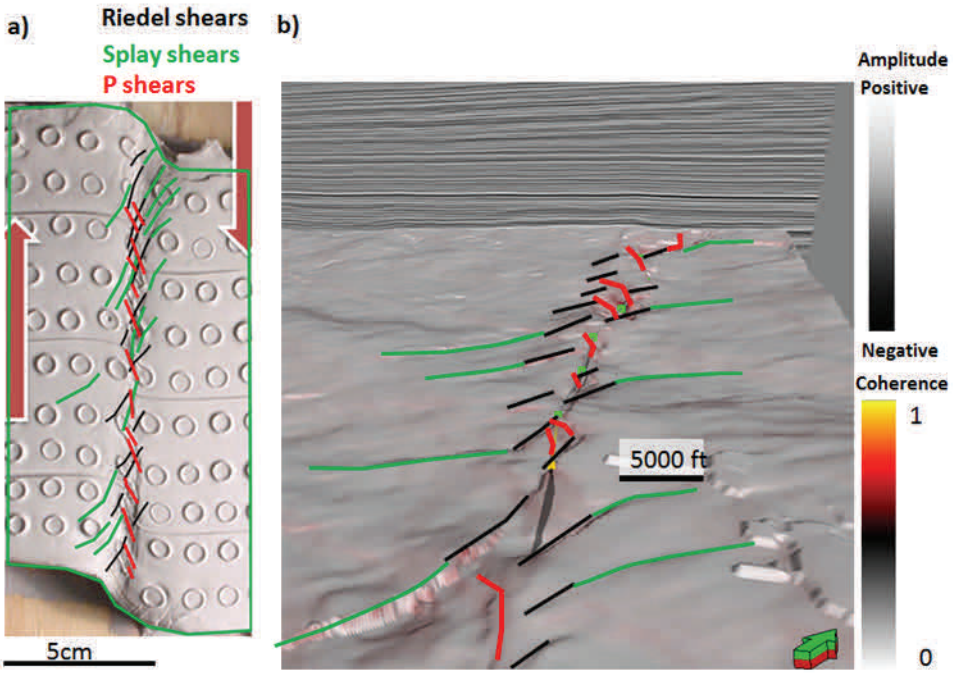


Figure 1 (a) Photograph from experiment and (b) A display of coherence co-rendered with seismic amplitude on the top of Woodford Shale strata. The black lines indicate potential Riedel faults, the green line for splay faults and rend for P shears. The connected line shows the studied strike-slip fault.

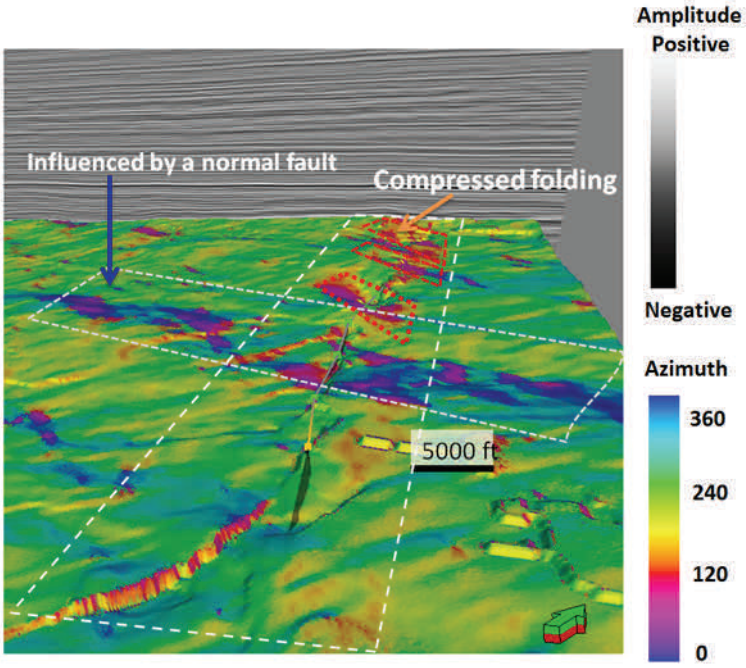


Figure 2. Dip-azimuth map of the top Woodford. Note the bands of same color within red dash line boxes, indicating same dip-azimuth, revealing potential fracture zones that we interpret to be P shear zones with compressed folds.

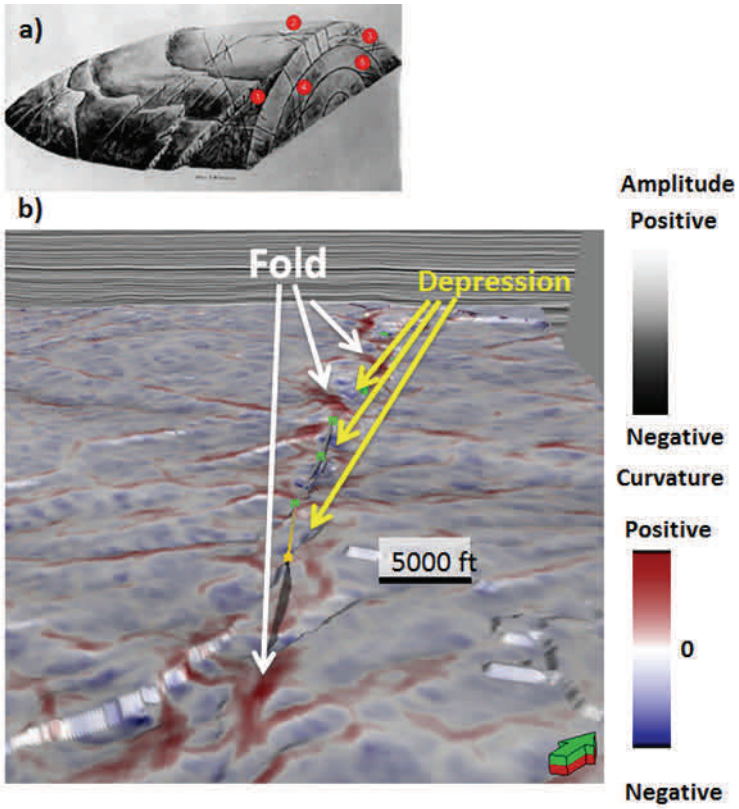


Figure 3. (a) A schematic diagram shows the anticline folds with fracture systems and (b) A display of curvature on the top of Woodford Shale. Areas with strong curvature (positive in rend color) correspond to strong lateral change of seismic amplitude and they are believed to indicate zones of relatively dense fractures.

Geophysical and modeling studies complementary to the SPREE Mid-Continent Rift project

Randy Keller and Kevin Crain

The Superior Province Rifting Earthscope Experiment (SPREE) project uses Earthscope's broadband Flexarray seismometers to provide seismic images of the structure of the crust and mantle beneath the Mid-Continent Rift System (MCRS). Gravity data (Fig. 1) show that the MCRS left a 2,000 km long trace of a massive igneous event that nearly split North America apart 1.1 billion years ago. The MCRS is of interest both intrinsically and as a type example of how continental rifts often fail for unknown reasons. We are working with our Northwestern University colleagues on a project funded by the National Science Foundation in which we are integrating the wealth of existing gravity and magnetic data with geological data to develop an integrated 3-D image of this massive rift system and constrain its evolution. We have modeled the gravity and magnetic structure along the different segments of the western and eastern arms of the MCRS as well.

The major goals of this project are to advance our understanding of the structure and evolution of the MCRS. The University of Oklahoma effort is focused on: 1) delineating the southern extent of the rift system beyond southern Kansas and its interaction with the southern Oklahoma aulacogen and 2) delineating the eastern extent of the rift system across Ohio and its interaction with the Grenville Front.

We have worked closely with our colleagues at Northwestern, and their student Miguel Marino, who came to our lab, to do the gravity modeling that resulted in a significant publication in which we assessed the variations in magma volume along the different segments of the western and eastern arms so as to constrain the geometry of rifting. Our student, Jonathan Buening, and a field assistant traveled to Ohio to collect gravity measurements across the central portion of the state. Beuning used these data in his master's thesis and graduated in August 2013. We are preparing a paper based on his thesis.

Our accomplishments include 1) making good progress toward building a 3-D model of southern portions of the rift system in southern Kansas and Oklahoma in an effort led by Crain, 2) a completed master's thesis (Buening) on the eastern extent that produced a new interpretation of its structure and interaction with the Grenville Front and 3) working with our colleagues on a new tectonic model of the overall evolution of the rift and publishing a paper that was presented at the recent Geological Society of America meeting on this model.

The deep structures we are delineating may be useful in arriving at a better understanding of earthquakes in the Mid-Continent region, especially central Oklahoma.

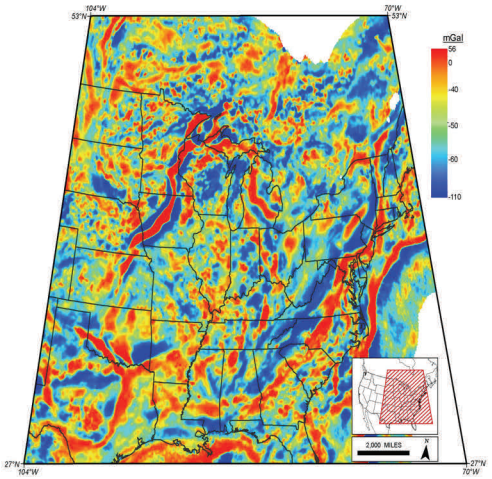


Figure 1. Gravity data.

Carbonates and Sequence Stratigraphy Field Trip

April 8-13, 2013

Lily Pfeifer

During the spring semester, 10 carbonates and sequence stratigraphy students participated in an intensive, week-long field trip led by Lynn Soreghan, CPSGG professor, to the Sacramento and Guadalupe Mountains of New Mexico and west Texas. We saw world-class outcrops of Mississippian Waulsortian mounds, and Pennsylvanian carbonates and clastics deposited during glacioeustatic cyclothems in Dry Canyon. We discussed the sequence stratigraphy of the west Guadalupe Mountains, prograding depositional systems at Last Chance Canyon and depositional environments of the San Andres shelf system along the Algerita Escarpment. On our strenuous hike up the Permian Reef Trail at the mouth of McKittrick Canyon, we observed the finest exposed example of a rimmed carbonate platform margin along the edge of the Permian Delaware Basin, including perfectly preserved fossils and all of the depositional facies characteristic of a shelf margin environment in order; from deep marine, through the Capitan reef and to the backreef environments.

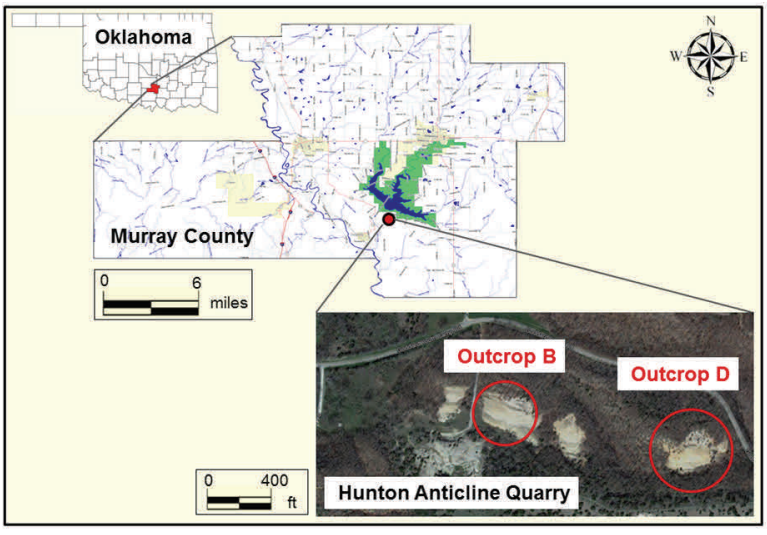
One assignment was the assessment of a well log and seismic data to observe stratigraphic and depositional patterns on the shelf, slope and basin of the Capitan reef system; infer about depositional environments; and determine where in the field we would expect to find the best oil and gas reservoirs. Individual student presentations were given in the field daily on a wide variety of topics from hydrocarbon potential of Permian algal mounds, to isotopic evidence for Pennsylvanian glacioeustasy, to the origin of pisolites and teepee structures. To conclude the trip, we stopped at White Sands National Park and Carlsbad Caverns. Seeing examples of everything we had been studying in the classroom in outcrop was the most informative and culminating learning experience to tie together our carbonates class.

Outcrop Derived Inorganic Geochemistry of the Woodford Shale; Murray County: Oklahoma

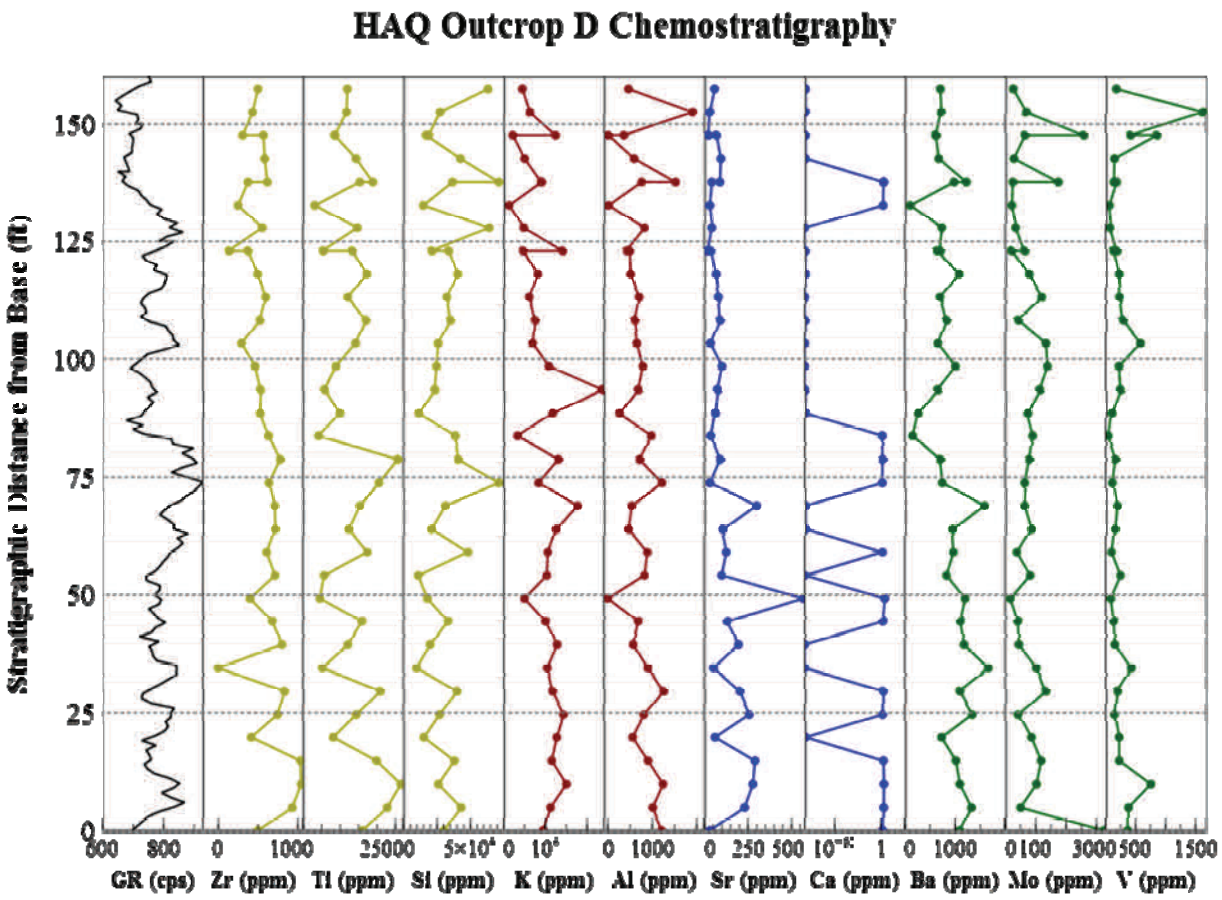
Jessica Tréanton, Bryan Turner and Roger Slatt

Recent advances in Hand-Held X-Ray Fluorescence (HH-XRF) technology allow for the investigation of inorganic whole-rock geochemistry in the characterization of the Woodford Shale Formation in the Hunton Anticline Quarry (HAQ) of Murray County in southern Oklahoma. By comparing chemostratigraphic profiles, lithostratigraphic descriptions and gamma ray response, it is possible to interpret relative changes in water depth, sediment input and depositional redox conditions. These parameters are essential in characterizing the unconventional Woodford Shale Reservoir.

Preliminary data from the Middle Woodford indicate an increasingly reducing, low energy and restricted depositional environment through time. This is reflected in mineralogical shifts with decreasing detrital input and carbonate content. These interpretations are based on elemental concentration fluctuations measured with a HH-XRF. Zr (13 – 100 ± 3ppm), Ti (300 – 2600 ± 70ppm), and Si (9,700 – 71,000 ± 500ppm) are useful in determining provenance and are concentrated in detrital components. Similarly, K (1000 – 2400 ± 250ppm) and Al (250 – 1900 ± 200ppm) are both concentrated in clays, and Sr (19 – 560 ± 3ppm) and Ca (traces – 140,000 ± 200ppm) in carbonate material. Elemental concentrations also reflect redox conditions at time of deposition with increasing V (40 – 1,600 ± 35ppm) levels indicating suboxic to anoxic environments, and Mo (16 – 320 ± 3ppm) anoxic to euxinic ones. Stratigraphic descriptions provide information on the source material, depositional processes and energy of the system. Finally, recording the GR response of the outcropping Woodford allows for correlation to subsurface well logs. These interpretations will facilitate the potential for high-resolution modeling of the Woodford Shale Formation.



Maps and air photograph showing the location of Outcrop D with respect to the Hunton Anticline Quarry in Murray County of south-central Oklahoma.



Preliminary inorganic geochemical results from the HAQ – D outcrop obtained using a HH XRF.

Photograph of the base of the section used in this study.

Bryan Turner, graduate student, testing the porosity of certain facies during research.

Depositional Systems and Stratigraphy Field Trip

Daniel Roberts

The Geology 4113/5113 Depositional Systems and Stratigraphy class taught by Lynn Soreghan took a four-day field trip to the Sacramento Mountains in Alamogordo, New Mexico, and the Guadalupe Mountains of southwest Texas. Along the way, additional stops were made at the White Sands National Monument and Carlsbad Caverns.

Our first day consisted of viewing the Mississippian Waulsortian mounds from a far distance, due in part to an unexpected mud flow cutting through our trail. Here we observed the relationship of the mounds with the Sacramento Mountains and the Orogrande Basin, as well as the teepee and dome shape structural characteristics of the mounds relative to shoreline proximity. We stopped by the White Sands National Monument for a break from learning.

The mud flow behind us shortened our hike in the Orogrande basin. We had to veiw the Mississippian Waulsortian mounds (top middle) from a greater distance than planned.

The second day we studied, described and constructed strat-columns of the late Pennsylvanian Holder Formation exposed at a road cut in the La Luz Canyon. We were split into seven groups over approximately 100 meters of road cut, with each group getting 10-15 meter sections. We would later combine our in-field strat-columns and interpret the facies with regard to the cyclicity of the boundary sequences of the Holder Formation. Our next stop was a small hike up Dry Canyon to view phylloid algal mounds. Our final stop was to view the Seven Rivers Formation of the Captain back-reef.

The long hike up the Permian Reef Geology Trail took up the majority of the third day. We started at the early Captain fore-reef and made our way through the reef complex, stopping to view the difference facies and structures of the Captain Reef on our way to the top (back-reef). The main observation of this hike was how the changing environments and tectonics over time influence the facies seen in the rock record. Our second stop was to view the Rader Limestone of the Bell Canyon Formation, and we discussed the large blocks of limestone debris flow structures of this road cut with relation to the equivalent Permian aged Capitan Reef. The third stop was to view alternating layering of carbonates and evaporites in the late Permian Castile Formation. At the final stop, we sketched the Capitan Reef exposed in the Slaughter Canyon and noted the progradation of the reef.

We are beginning our long hike up the Permian Reef Geology Trail from McKittrick Canyon to the top in the Guadalupe Mountains. We are standing on top of the Forereef of the Captain Reef Formation.

The final day we stopped to view the Yates Formation that was deposited on the Northwestern Shelf. We finished our trip with a tour of the Carlsbad Canyons.

Overall, the field trip gave us experience describing and interpreting facies, recognizing boundary sequences, and relating the boundary sequences to climatic, tectonic and atmospheric changes. The trip was designed to take us on a tour of the geological history of Sacramento and Guadalupe Mountains, starting in the Mississippian and ending in the late Permian.

This is at the top of the Permian Reef Geology Trail. We are standing on the Backreef of the Captain Reef Formation with the Guadalupe Mountain range on the right and the Delaware Basin on the left.

An experimental approach toward calibrating a garnet-tourmaline geothermometer

James Maner

I have been experimentally calibrating the exchange of Mg, Fe and Mn between garnet and tourmaline toward a geothermometer that is applicable to peraluminous granites and medium-grade metapelites. Initial experiments involving reactions among sand-sized grains of andalusite, rhodonite, Mn-fayalite and/or forsterite in hydrous boron-bearing, peraluminous granitic melt were conducted at 200 MPa (H_2O) in the temperature range 650°C-750°C. Products from these initial experiments include garnet, tourmaline, (Mn,Fe)-Al-spinel, magnetite, alkali feldspar, plagioclase, quartz, corundum and pyroxene and/or amphibole. The $f(O_2)$ lies below MH and above FMQ as indicated by the complete oxidation of fayalite to magnetite plus quartz. Graphite was added to one series of experiments to lower $f(O_2)$ (to near the CCO buffer); in these experiments, magnetite rimmed fayalite, (Mn,Fe)-Al-spinel formed and graphite but no excess water was present on quench, indicating that $f(O_2)$ was reduced in dominantly carbonic vapor. EMPA of garnet-tourmaline pairs from fayalite- and graphite-bearing experiments yield values of $K_D^{Mn/Fe}{}_{Grt/Tur}$ and $K_D^{Fe/Mg}{}_{Grt/Tur}$ that have large standard deviations and show only minor apparent fractionation as a function of temperature. The variability in K_D values stems from heterogeneity among individual garnet and tourmaline crystals due to sluggish diffusion of Mg, Fe and Mn through melt.

Experiments are currently focused on reducing heterogeneity of products by creating a nearly crystal-free, homogenous pre-conditioned glass at 800°C and 200 MPa, which is quenched and then run forward to the temperature of interest. Graphite and fayalite are not used to buffer $f(O_2)$ in latter experiments, but the presence of (Mn,Fe)-Al-spinel, cordierite, (Mg,Fe,Mn)-pyroxene, aluminous garnets (2 apfu Al at Y site) and lack of magnetite suggests that iron is mostly present as Fe^{2+}. Garnet and tourmaline grown in this fashion are more homogenous throughout the charge, though they exhibit compositional zoning. Garnet and tourmaline have not yet been synthesized from a single bulk composition, so K_D relationships cannot be determined from the pre-conditioned experiments.

Uncertainty in the garnet-tourmaline partitioning arises from the saturation of Mn in tourmaline at low Mn concentrations (Figure 1), by the exceedingly low Mg content in garnet (Figure 2), and by the uncertainties in existing K-$_D$ values (Figures 3 and 4). In addition to a thermometer based elemental partitioning, I am also pursuing calibration of $\Delta^{18}O$ between garnet and tourmaline pairs. Other current topics of research include the use of H- and F-bearing garnets as indicators of H and F activity of fluid/melt and B isotope systematics between tourmaline and granitic melt.

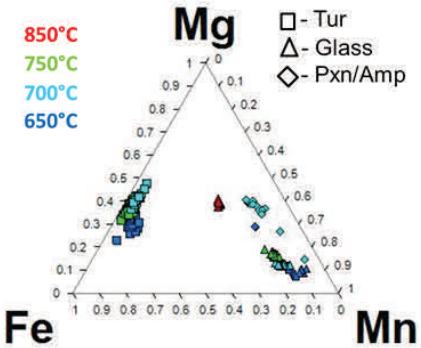


Figure 1: Tourmaline, pyroxene/amphibole and glass compositions as a function of temperature.

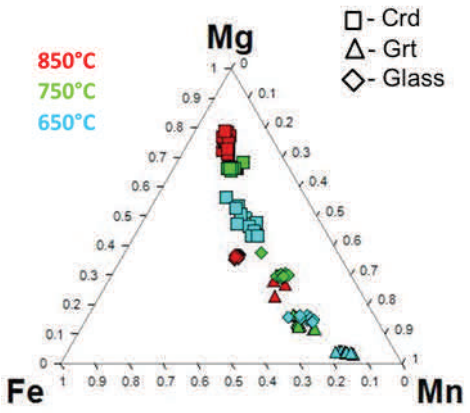


Figure 2: Garnet, cordierite, and glass compositions as a function of temperature.

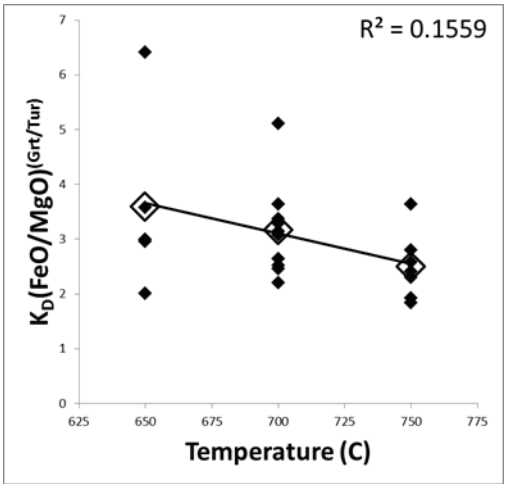


Figure 3: $K_D(MnO/FeO)^{Grt/Tur}$ versus Temperature (C).

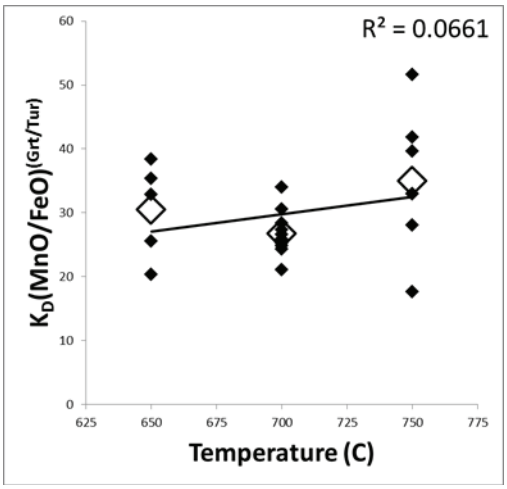


Figure 4: $K_D(MnO/FeO)^{Grt/Tur}$ versus Temperature (C).

GEOL 4923/5923 TANCO Fieldtrip

David London

Once again, the Tantalum Mining Corporation of Canada (TANCO), a subsidiary of Cabot Corp., hosted the class GEOL 4923/5923 (Pegmatites) at its TANCO mine, located approximately 70 km northeast of Winnipeg, Canada. TANCO is one of the largest and most important rare-metals mines in the world. Historically important for its production of tantalum and lithium ores, TANCO is now mined exclusively for cesium, which comes from pollucite ($CsAlSi_2O_6$). TANCO refines that pollucite into cesium formate, which is sold to oil companies as a heavy liquid for deep drilling in the North Sea. In addition to instructors **David London** and **George Morgan**, the OU contingent included undergraduates **Chrissy Carnine, Jay Minton, Tyson Mizzell** and **Molly Sexton**.

Petalite, pollucite and quartz.

TANCO location.

Skeletal quart into layered aplite.

Applying regional chemostratigraphic variability to refine sequence stratigraphic frameworks within the Woodfod Shale, Okla.

Bryan Turner, Jessica Treanton and Roger Slatt

The Woodford Shale provides an opportunity to test recent advances in handheld XRF (HHXRF) technology to develop sequence stratigraphic frameworks by comparing chemostratigraphic profiles directly to gamma ray logs and measured stratigraphic sections obtained from the same locations. Gamma ray profiles allow a direct integration of these newly obtained chemostratigraphic profiles into previously interpreted sequence stratigraphic frameworks. One field site (Figure 1) and three cores of the Woodford Shale have been scanned using the HHXRF (Figure 2) to develop a preliminary analysis of the regional variability of chemostratigraphic profiles for this formation.

Three cores from Caddo, Washington and Pottawatomie counties in Oklahoma and one outcrop at the Hunton Anticline Quarry (HAQ) in Murray County, Okla., represent both proximal and distal environments of the Woodford Shale. Clean surfaces at each area are scanned at 1-foot intervals using the HHXRF to determine the elemental profiles. At the same resolution, a gamma ray profile is scanned using a GR scintillometer or core spectral gamma ray. The lithologic description, gamma ray profile and elemental profiles are then used to develop the sequence stratigraphic interpretation.

Correlations based on regional scale variations in chemostratigraphic proxies show an overall increase in sedimentation in proximal settings with a decrease in sedimentation in distal settings. Drops in continentally derived sedimentation are interpreted from dilution of the Zr and Ti signals, associated with clastic sedimentation, relative to the concentration of K and Al, which are associated with clay mineral accumulation. All these elements are regarded as relatively immobile elements. In the distal setting, the chemostratigraphic ratios between clastic and clay proxies show a dilution of Ti and Zr between 10 to 60 percent in the upper Woodford relative to the lower Woodford, while in the proximal setting these ratios are concentrated up to 12-15 percent in the upper Woodford relative to the lower. These changes are indicative of a landward shift in sedimentation.

Figure 1: The Woodford Shale at the Hunton Anticline Quarry. Photo credit: Bryan Turner.

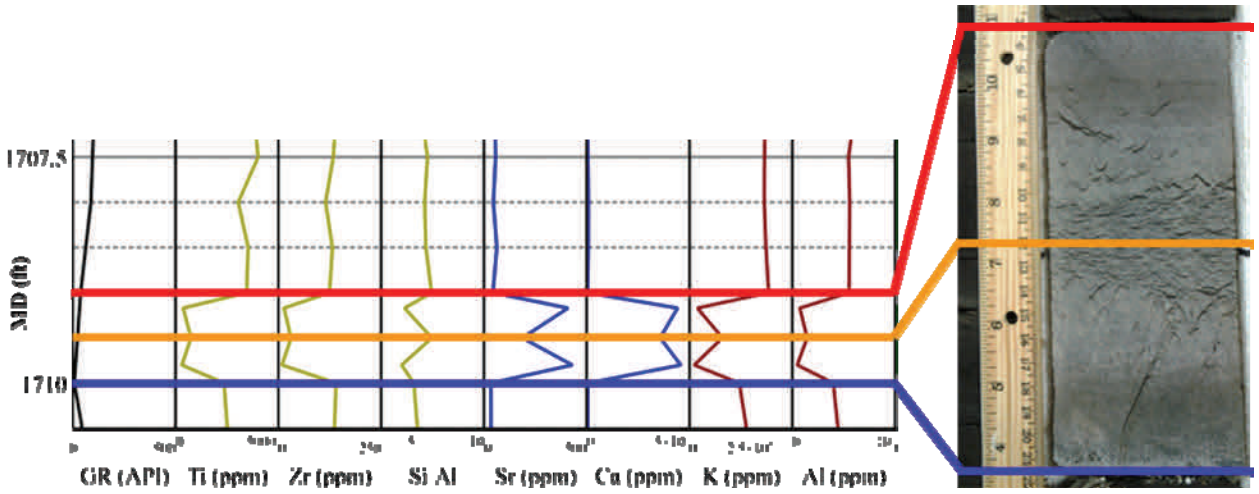


Figure 2: Detailed chemostratigraphic analysis is capable of identifying the transition from shale to limestone grading into a muddy limestone grading back into a limestone, while the core gamma ray values for this interval show little variation. This emphasizes the potential increase in resolution capable from chemostratigraphic analysis.

ConocoPhillips School of Geology and Geophysics Institute of Reservoir Characterization

Roger M. Slatt, Institute Director

In 2012-13, the Institute of Reservoir Characterization within the CPSGG had another outstanding year. As an indicator of recognition of its educational program, both teaching and research, this past year, two rooms were dedicated in honor of the IRC. The first of the two dedications was named the Noble Energy Company Reservoir Characterization Center Laboratory, and is located in the basement level (Room N102) of Sarkeys Energy Center. The second of the two dedications was named the Robert L. and Norma E. Stephenson Geologic Reservoir Characterization Core Facility, and is located in the basement level (Room B102) of SEC. Plaques in honor of the long-standing donors and supporters of the institute, Noble Energy Co. and the Stephenson family respectively, have been placed at the entrance to both facilities.

The success of the institute hinges on the success of its students. To date, more than 70 master's in science and doctoral candidate students associated with the institute have graduated, almost all of whom are gainfully employed in the petroleum industry. In 2012, the following students completed their program requirements and are working for the companies listed after their name: C. Althoff (PostRock), L. Guest (Samson), E. Torres (Noble), A. Serna (ConocoPhillips), C. Molinares (ConocoPhillips), J.D. Amorocho (ConocoPhillips) and L. Castillo (Pathfinder). Fifteen additional graduate students are currently affiliated with the institute and are either working, or beginning to work, on thesis research topics. Three new students will be entering the program in spring 2014.

Most, but not all, of these students conduct thesis research on unconventional resource shales, mainly focusing on the Woodford, but also including Silurian Shales of China, the Brown Shale of Sumatra and the LaLuna Shale in Colombia. Funding for these projects comes mainly from a consortium of 14 oil and gas companies, which formed an 18-month consortium project through the institute in January 2013. A field trip and information meeting were held this past October for the consortium companies.

Numerous presentations with abstracts on unconventional resource shales were made this past year by students at conventions and meetings. By invitation, a key paper was published by 2011 graduate Andrea Cadena in the inaugural edition of the new journal *Interpretation*, titled *Seismic and sequence stratigraphic interpretation of the area of influence of the Magdalena submarine fan, offshore northern Colombia*. Roger Slatt co-authored a chapter in a new *AAPG Memoir 102 on Electron Microscopy of Unconventional Resource Shales*, completed the second edition of his book titled *Stratigraphic Reservoir Characterization for Petroleum Geologists, Geophysicists and Engineers*, and wrote a chapter titled "Sequence Stratigraphy of unconventional resource shales" for a 2014 book titled *Fundamentals of Gas Shale Reservoirs* (Wiley and Sons).

On a sadder note, in late June, Slatt's wife of 26 years, Linda Gay Slatt, passed away after a long battle with cancer. A Linda Gay and Roger M. Slatt Graduate Student Support Endowment was established in her honor, which, thanks to many donors, has already accumulated more than $50,000 in principal. Linda Gay cared deeply for the students who were associated with the institute and who kept her husband active and healthy!

About the IRC:

Directed by Roger Slatt, the Institute for Reservoir Characterization is known and respected internationally with its interdisciplinary approach to the science of reservoir characterization. Institute geophysicists, geologists, engineers, mathematicians and computer scientists use the Gypsy Project, a unique test reservoir owned by OU, to develop and test reservoir characterization tools and methods. An interdisciplinary course on applied reservoir characterization is the first such course ever offered at a university, and an intensive version of the course for industry professionals is in great demand across the United States and abroad.

IRC Current Graduate Students

From top left: Esther Ali, Caleb Bontempi, Richard Brito, Luis Cardona, Hang Deng, Adriana Gomez, Nathan Hasbrook, Scott Hasbrook, Jonathan Hill, Lennon Infante, Colleen Klockow, Elizabeth Mann, Brent McCullough, Brett Riley, Brandon Swain, Jessica Treanton, Bryan Turner, Henry Vandervoort and Fuge Zou.

Field trip to Schlumberger Learning Center in Kellyville, Okla.

Neil H. Suneson, *Oklahoma Geological Survey*

Often, too much of a student's education occurs in the ivory tower. This can be a problem when the purpose of that education is to solve real-world problems. Many of OU's geology students look forward to careers in the petroleum industry, and this spring a number from Roger Slatt's reservoir characterization class and from Rick Andrews' and Neil Suneson's subsurface methods class took advantage of a luxurious bus ride and great lunch to visit Schlumberger's Learning Center in Kellyville, Okla., to learn something about how wells are logged, cleaned, cemented and perforated. The goal was to gain some perspective and background on the petroleum industry outside the classroom.

The key player in this enterprise was OU alumnus Bob Davis, who works for Schlumberger. For years, Davis has hosted the petroleum engineering students at the center; this year he agreed that it was time the geology students took advantage of the center's hospitality. So we did, and we were not disappointed.

Eighteen students and three OGS geologists (Brian Cardott, Andrews and Suneson) arrived at the center at 10 a.m. and were given a brief overview of the history of Schlumberger and the training that their field engineers undergo at the center. This was followed by a buffet lunch of grilled burgers, barbecue beans and much more. The open-door policy of the ice cream freezer was taken advantage of (some might say abused). After lunch we headed "down the hill" to where most of the field training occurs. Blue machinery and equipment, identical (though probably somewhat cleaner) to that found at drill sites, was everywhere. We split into three groups of seven or eight each to visit the different stations around the area.

What do Schlumberger's engineers learn about at this specific center? Exactly the same things their trainers told us about:

Cementing
The use of coiled tubing for cleaning and testing
Hydraulic fracturing
Perforating
Logging

OU group in front of the rig used to train engineers in the use of coiled tubing. The truck with coiled tubing is behind and just to the right of the rig. There are six *real* wells on the property that Schlumberger uses to train their field engineers.

While certainly a different kind of "field work" than most geology students are used to, the analyses and technology that go into an oil or gas well certainly impressed the students. Take cementing… you do not just pump cement down a hole to secure the casing. How much cement will fill the annulus? What is the chemistry of the formation fluid and what is its effect on the cement? How long will the cement take to harden? (You do not want it hardening too soon.) Have you thoroughly isolated your reservoir from, say, a shallow aquifer?

An important station for the subsurface students to see was the display of logging tools. These tools provide much of the data critical to our interpretations of the subsurface – from correlating logs, to making cross sections, to making subsurface maps. Despite all the modern measurements that are now available from service companies like Schlumberger, and despite all the calculations and diagrams that can be made available instantaneously to the wellsite geologist, the fundamental logs continue to be gamma ray, resistivity, density/porosity and sonic.

The trip ended where it started – in the conference room "up the hill." Our hosts told us a little about their careers with Schlumberger. All have travelled extensively and not just to midland-Odessa, Texas. All have been in a variety of jobs with Schlumberger, and all felt like they had contributed to what, obviously, is the leading oilfield service company in the world.

Our heartiest thanks to our alumnus, Bob Davis, for having set up the field trip and to our Kellyville hosts: Genean Lisboa, Ratchet Martin and Trey Stearns. The many trainers who took the different groups around were superb, not the least of whom was perforating expert and OU graduate Jeff Knous. Finally, thank you to Schlumberger for opening up your operations so some of us could briefly escape the ivory tower for a few hours.

Logging tools of many different vintages on racks outside training rooms. As our engineer explained to us, the basic tools are fundamentally the same as those used years and years ago – gamma ray, resistivity, density/porosity and sonic.

Colloidal transport of nanoscale to microscale grains in the Central Oklahoma Aquifer

Andrew Swindle, Molly Sexton, Virginia Priegnitz, Andrew Madden and Jeffrey Westrop

The Central Oklahoma Aquifer provides a source of water for many of the most populated regions of Oklahoma. Elevated levels of arsenic, chromium and uranium above the Environmental Protection Agency limits prevent usage of some public supply groundwater wells screened within the predominately red sand and siltstone units of Permian age. Despite significant hydrogeochemical modeling efforts, groundwater well locations yielding elevated trace element concentrations are spatially difficult to predict. We hypothesize that the presence of horizons containing abundant diagenetic iron oxides and post-diagenetic clays elevate available surface areas, serving as sinks for trace metals when groundwater geochemical conditions favor adsorption and sources when conditions favor desorption. Additionally, these nano- to micro-scale grains likely contribute to colloidal transport of adsorbed trace elements. Two forms of investigation explored trace metal distributions and aquifer mineralogy at the nano- to microscales in hopes of developing more robust explanations for trace element distributions in sediment and groundwater.

The first investigation involved the collection of 50 sediment samples from the U.S. Geological Survey/EPA Norman Test Hole Core spanning the productive zones of the aquifer. These samples were analyzed for BET surface area, micromorphology with SEM, color, texture and grain size with optical microscopy, and whole-rock trace element geochemistry. Initial results demonstrated anomalously high surface areas in many samples, ranging up to ~60 m-2/g. High surface area values were obtained in both clay-rich and clay-poor intervals. SEM imaging of samples from these intervals revealed the presence of abundant microscale hematite rosettes assembled from nanoscale platelets, in addition to clay minerals and other nanoscale iron oxides. Trace element concentrations followed a general power-law relationship with surface area, and with much scatter.

In the second investigation, TEM grids were deployed in monitoring wells associated with a City of Norman municipal drinking water supply well using an in-house designed subsurface nanoparticle collector. After exposure to groundwater for one week, TEM analysis of the grids revealed abundant iron oxides, quartz with or without surface-bound iron oxides, gypsum and other trace phases.

The actual well used during this research.

Continental Drilling to Explore Earth's Sedimentary, Paleobiological, and Biogeochemical Record

Scientific Drilling and the Evolution of the Earth System:

Climate, Biota, Biogeochemistry and Extreme Systems; Norman, Okla., May 17-19, 2013

Gerilyn Soreghan (University of Oklahoma)

and Andrew Cohen (University of Arizona, Tucson)

A workshop, funded by the U.S. National Science Foundation, was held in Norman, Okla., with the goal of promoting research using continental scientific drilling to explore the Earth's sedimentary, paleobiological and biogeochemical record. The workshop was intended to encourage U.S.-based scientists to take advantage of the exceptional capacity of unweathered, continuous sediment cores to serve as archives of the Earth's history. The 41 participants submitted 30 project preproposals as an exercise to assist scientists new to continental scientific drilling in developing viable NSF and International Continental Drilling Program grant proposals that would employ drilling across a range of topics in Earth, evolutionary and ecological history. These preproposals to use drilling to study paleobiology, paleoclimatology, stratigraphy and biogeochemistry questions formed the basis for discussion throughout the meeting. The proposals, covering geological history from the oldest sedimentary rocks to modern lakes, are available at http://www.csdworkshops.geo.arizona.edu/files/Download/PreProposals-opt5.pdf.

Introductory talks on drilling and coring methods, plus best practices in core handling and curation, opened the workshop to enable all to understand the opportunities and challenges presented by scientific drilling. Participants worked in thematic breakout sessions to consider questions to be addressed using drill cores related to glacial/interglacial and icehouse/greenhouse transitions, records of evolutionary events and extinctions, records of major biogeochemical events in the oceans, reorganization of the Earth's atmosphere, exceptional fossil biotas, and records of vegetation/landscape change.

Participants agreed that there is a pressing need to obtain unweathered and continuous sections across critical intervals of Earth and life history and to capture spatial variation globally. Continental and epeiric sea cores can provide a broad range of environmental and climate states, representing local to global conditions tied to biotic history inferred from both drill cores and outcrops. There was also broad consensus that continental drilling to address key Earth/life history questions is best developed through large-scale initiatives, encompassing life's response to the full range of Earth's surface conditions.

Several participants provided personal perspectives on prior successful drilling projects that addressed major stratigraphic and paleobiologic questions. Successful projects built strong, interdisciplinary teams of committed scientists with a variety of logistical and communications skills early in the project's development and had clear, simple advance plans and contingency plans laid out at all planning and drilling operation stages. Additional breakout sessions and talks considered the technical challenges and sampling requirements specific to the paleobiology, geochemistry/geochronology, and sedimentology/stratigraphy communities in current and future studies of drill cores. Unweathered drill core provides extraordinary opportunities to examine the biogeochemical evidence for major Earth-life transitions (e.g., Pre-Cambrian atmospheric oxygenation), but taking advantage of this will require new core handling and storage techniques to avoid contamination and to maintain cores for analytical techniques of the future.

Temperature and pH effects on alunite dissolution and implications for Mars

Jamie Miller, Megan Elwood Madden, Andy Elwood Madden and Brittany Pritchett

Water is necessary for all known life; therefore, determining the duration of liquid water on Mars is crucial to understanding its habitability. Alunite ($KAl_3(SO_4)_2(OH)_6$) is a hydrated sulfate occurring in wet, acidic environments rich in S and Al. Sulfates have been observed on Mars in areas such as Meridiani Planum and Iani Chaos, providing evidence of liquid water in the past. pH and temperature affect the degree to which minerals dissolve in water, controlling their lifetimes. The purpose of this study is to determine the rate of alunite dissolution in water at varied pH (1-8) and temperature (278- 323 K). Results for alunite are compared to previous works investigating jarosite ($(K, H, Na)Fe_3(SO_4)_2(OH)_6$), the ferric sulfate end-member of the solid solution series. Dissolved K concentrations were used to determine surface area normalized dissolution rates and compared to A-cation site concentrations in previous jarosite studies. First, pH was set at 1, 2, 4, 5, or 8 at 20 °C. The initial K rate steadily increases with increasing pH; however, the long-term K rate (Fig. 1) increases at pH <6 or >6 (minimum at 6). Initial dissolution rates for alunite (expressed as log rate in units of mol m^{-2} s^{-2}) range from -9.8 to -11.5 over pH 1-8. Comparable dissolution rates from previous studies (Fig. 1) range from -7.5 to -9.1 for K-jarosite, and from -6.6 to -7.4 for Na-jarosite. A comparison of all three sulfates shows that Na-jarosite is the fastest, followed by K-jarosite, and finally, alunite is the slowest to dissolve. Dissolution rates of the three sulfates reach minimums at different pHs: alunite at pH 6, K-jarosite at pH 3.8, and Na-jarosite at 3.5. Alunite dissolution rates were further studied at 278, 295, 313, or 323 K (Fig. 2) in unbuffered ultra-pure water. Initial dissolution rates range from -9.84 to -10.8 over 278 to 323 K. Comparable dissolution rates from previous studies range from -9.2 to -8.59 for K-jarosite, and from -8.80 to -9.50 for Na-jarosite. K-jarosite rates are the fastest, followed by Na-jarosite, then alunite. Dissolution rates of the three sulfates all steadily increase as temperature increases; minimum rates occur at the minimum temperature, 298 K. Overall, alunite rates suggest that Al-rich sulfates are likely to survive the longest on Mars and will buffer the system to higher pH, while jarosite dissolves more quickly and buffers the system to a lower pH. Therefore, alunite can survive longer in more basic conditions than jarosite.

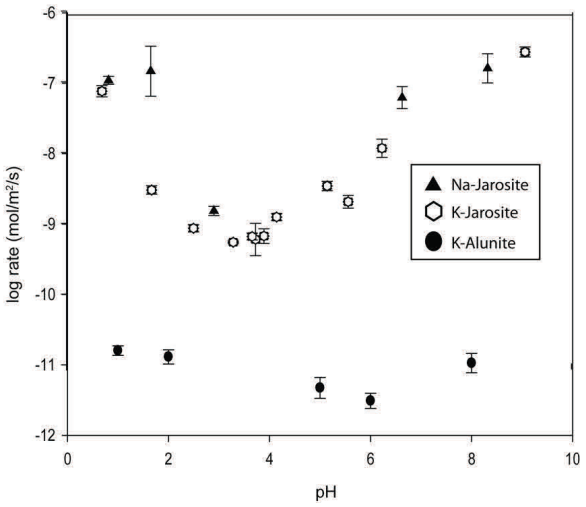


Figure 1. Dissolution rate of K-Alunite (this study) , K-jarosite (Elwood Madden et al. , 2012), and Na-Jarosite (Zahrai et al. 2013) over varied pH. V-shaped trend of increasing rates at both high and low pH is observed with all three minerals. However the minimum rate shifts from pH ~3.5 for jarosite to ~6 for alunite, likely due differences in solubility of Fe^{3+} and Al^{3+} .

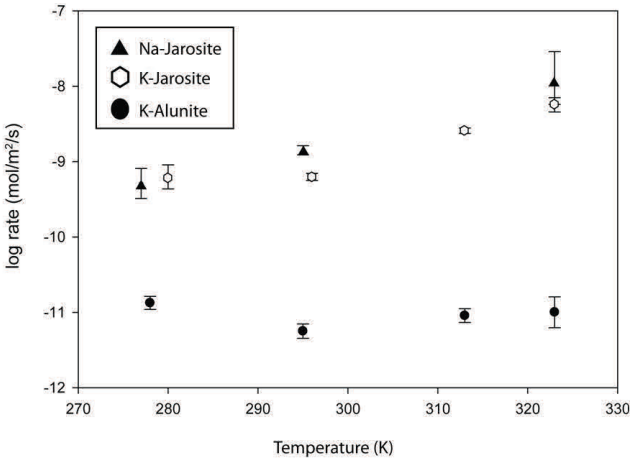


Figure 2. Dissolution rate as a function of temperature. While jarosite dissolution rates increase with temperature, alunite dissolution rates appear to be unaffected by temperature changes from 277-323 K. This may be due to expanded thermodynamic stability of alunite at higher temperatures limiting the dissolution rate.

References:

Elwood Madden ME, Madden AS, Rimstidt JD, Zahrai SK, Kendall MR, and Miller MA (2012) Jarosite dissolution rates and nanoscale mineralogy, Geochimica et Cosmochimica Acta, 91, 306-321.

Zahrai SK, Elwood Madden ME, Madden AS, Rimstidt JD, Na-jarosite dissolution rates: The effect of mineral composition on jarosite lifetimes, Icarus, Volume 223, Issue 1, March 2013, Pages 438-443.

Identification of geo-hazards using multi-attribute displays and a supervised neural network

Luis Castillo, Infante Lennon and Byron Solarte

Introduction

The project is located in an older developed field. The discovery well, the Huffman #1 was drilled in 1932 with later development ending in the 1950s. The original targets were shallow Pennsylvanian sandstones and Devonian-Ordovician Carbonates.

The Carver Davis project is a structurally complex field characterized by multiple faults and productive carbonate reservoirs of Ordovician age in central Oklahoma. This field has produced 502 MBO primarily from Ordovician (Trenton Viola and Simpson Dolomite) discontinuous cherty and/or dolomitic porosity zones of the Trenton and from perforations at the very top of the Simpson Dolomite to avoid water production. The Viola Group reservoirs are composed of the Fernvale limestone member, dolomite stringers of the Trenton member and a massive Simpson Dolomite at the base.

Studies of well logs, completion records and historical production indicated that the reservoirs were compartmentalized due to their structural and lithological complexity associated with its proximity to the Arbuckle Uplift.

The objective of this study is to identify geohazards to effectively drill horizontal wells in the productive targets. The Carver-Davis field was drilled to capture oil and gas trapped in compartmentalized and transition zone reservoirs of the Ordovician Viola group by drilling up-dip horizontal wells on the south flank of the structure. Horizontal wells are expensive and need to fall within tightly controlled vertical intervals. Geologic features that negatively impact such drilling (in this case faults, karts and lithological thickness variation) are called “geohazards”. To this end, a small cost-effective 2.2 mi^2 3-D seismic survey was designed and acquired to map such geohazards. The main techniques used to characterize the carbonate ramp were seismic attributes and seismic inversion analysis.

The results of the seismic interpretation showed more structurally complex reservoirs with new faults along the horizontal well paths that were not previously mapped. The reinterpretation and inversion analysis of the project was critical to redefine the locations for one vertical and one horizontal well, to geo-steer the drill bit to effectively reach the targets while avoiding geohazards and providing high-resolution estimates of lithology. Identification of geohazards with multi-attribute display and neural network prediction reduced the risk/cost of the project by drilling in the right place. The complex reservoir characterization of the project allowed the operator to redesign the well path and to anticipate and thereby mitigate fault interception by the horizontal well.

Geological background

The Carver-Davis prospect is a faulted structural closure lying on the axis of a regional north-northeast plunging anticline called the Seminole Arch. The upper Ordovician reservoirs here have been subjected to multiple orogenies, resulting in traps characterized by various combinations of extension, compression and strike-slip movements. The Ordovician-Early Devonian group was deposited on a shallow cratonic shelf that exhibited a very slow rate of subsidence; therefore, the deposition of this carbonate group is associated with a ramp-style carbonate buildup (Figure 1). In this type of environment, the accumulations of sediment remain equal (relative to thickness and sedimentation rates) across the entire Anadarko shelf and Cherokee platform from high-energy down to low-energy environments. The deposition in the study area was affected by later faulting caused by the Arbuckle uplift.

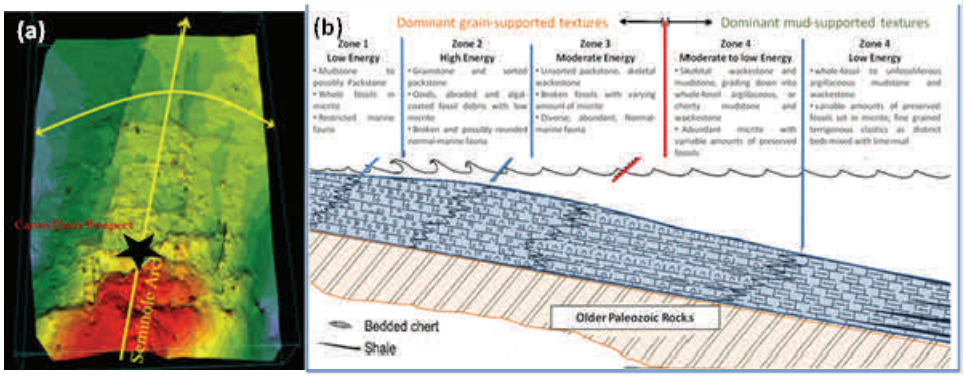


Figure 1: (a) Regional structure map of the top Ordovician. (Black star indicates the location of the survey at regional scale) (b) Model generalized of the Ordovician carbonate ramp. (Modified from Thomas 2001).

Seismic data

A 2.2 mi^2 3-D seismic survey was acquired, processed and interpreted over the prospect to confirm the structural positions of the objectives and to subtle delineate faults. Acquisition parameters are shown on Figure 2a and b. Frequencies between 10 and 100 Hz have been effectively balanced (Figure 2d). Random noise was reduced using 3-D random noise attenuation (FXY Decon). Acquisition footprint is minimal below 0.6 s including the carbonate ramp target. Footprint is present in the shallow section (Figure 2c). In general, the data are of good quality. Major reflectors look continuous and fault edges are well preserved with minimal migration artifacts. The seismic data were tied to existing well control at each prospective horizon, and were used to design the path of deviated and horizontal wellbores. Horizons were picked on a shallow Checkerboard limestone marker, and on the strong Hunton limestone and Viola limestone reflectors to guide velocity picking. The Hunton limestone, Viola limestone and base of Arbuckle horizons were mapped using standard seismic interpretation software. The Hunton and Viola limestone were mapped in order to identify the carbonate ramp and its vertical and horizontal variations. The base of Arbuckle limestone (top of basement) illuminates basement-involved faults that caused structural deformation of the carbonate ramp.

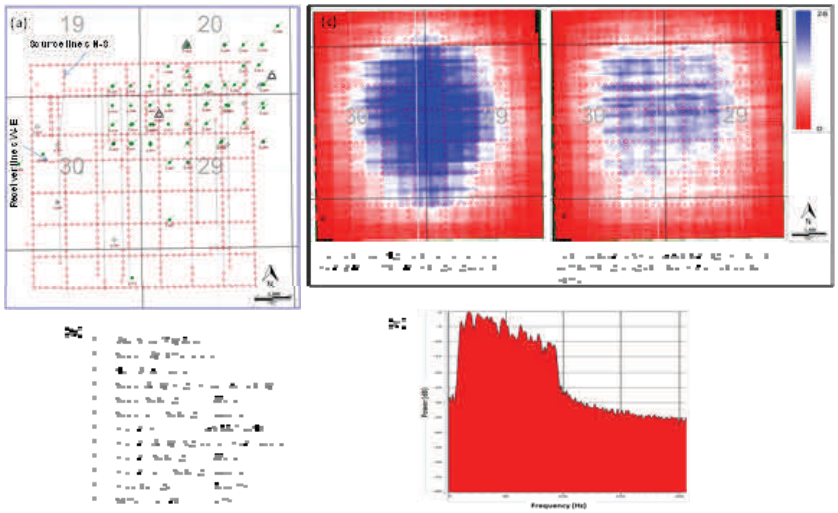


Figure 2: (a) Survey map, (b) acquisition parameters, (c) fold plots at target depth and 0.6 s, and (d) power spectra of a representative N-S line.

Seismic Multi-Attributes Characterization of the Carbonate Ramp

In order to highlight the presence of faults and other potential geohazards coherence, most-positive and most-negative curvature volumes were computed and interpreted at each of the key horizons (Figure 3).

Using coherent energy attribute, circular features were identified as karsts. The carbonate geometry is characterized by low-energy values (Figure 4). Also, most positive curvature attribute was a useful tool in identifying karst features. These collapse features (Figure 4) can be recognized as negative values of most-positive curvature (Baruch, et al 2009).

The Sobel filter attribute delineated the fault pattern and reservoir compartments. Synthetic faults caused by deformation and karsting were also identified. The faulting caused by reactivated basement-involved faults deformed the original carbonate ramp. The types of structures developed are related to clay-poor massive dolomite and limestone (Figure 5a).

Quantitative methods, such as seismic impedance inversion, can also aid in assessing the drilling risk (Mc Connell, 2004). Geohazard issues include: lithological thickness variability, stratigraphic features such as karst and synthetic faults, fluid distribution, lithology and anomalously low porosity zones. Acoustic impedance inversion analysis of the project was critical to redefine the locations for one vertical, one horizontal well and to geo-steer the drilling bit to effectively reach the targets

We used a model-based inversion workflow, with the goal of highlighting the contrast of impedance between the carbonate ramp and the surrounded formations, as well as mapping the lateral thickness variations of the Viola limestone and the identification of karst structures characterized by low impedance values.

Supervised Neural Network Analysis

The workflow used to train the network is shown on figure 7a. During training, the weighting function is adjusted to optimize the prediction of porosity as a direct reservoir quality indicator. High porosity zones correlate with the location of karst features (Figure 7b). The analysis window of the training was aimed to be within the interest zone in order to obtain a better correlation. The neural network performs this process at every sample location in the seismic volume (Heggland, 2004).

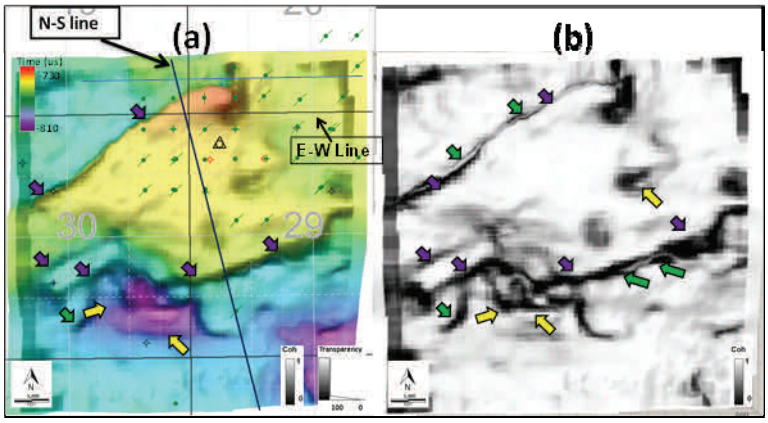


Figure 3: (a) Viola time-structure co-rendered with coherence. (b) Horizon slice along the top Viola through the coherence volume. (Yellow arrows indicates karst features, green arrows indicates synthetic faults caused by karsting deformation and purple arrows indicates the major faults.)

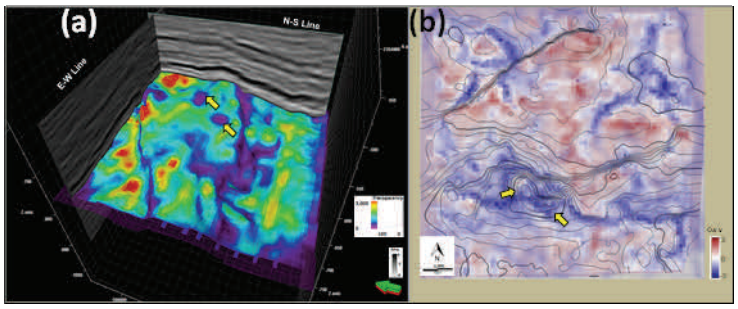


Figure 4: Horizon slices along the top Viola through (a) coherent energy and (b) co-rendered most-negative and most-positive curvature volumes. (Yellow arrows indicates karst features).

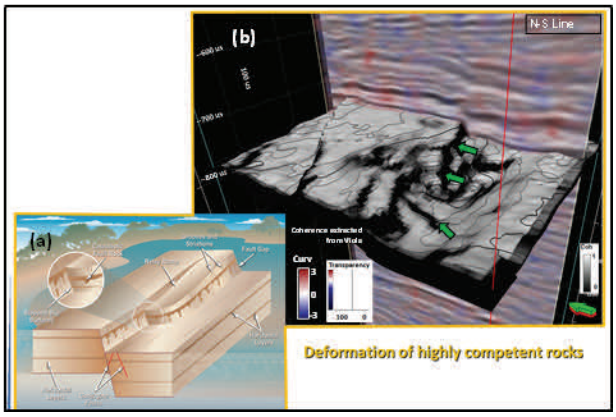


Figure 5: (a) Model of deformation of a carbonate ramp seen in a quarry (After Ferrill and Morris, 2008). (b) 3-D view of Sobel filter attribute extracted from along the top Viola horizon. (Green arrows indicate synthetic faults). Note the relay ramps parallel to the faults. Vertical slice shows seismic amplitude co-rendered with most-positive and most-negative curvature.

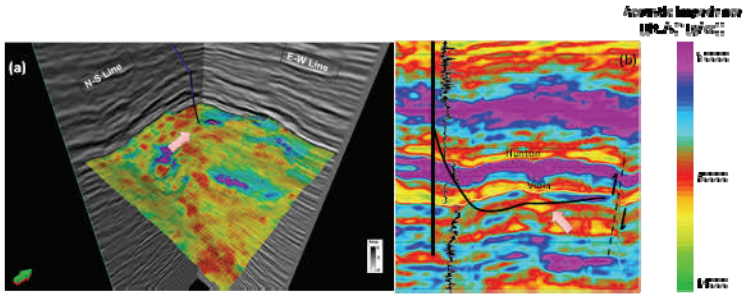


Figure 6: (a) 3-D view of horizon slice along the top Viola through the acoustic impedance volume, (pink arrow indicates the low impedance karst features). (b) Vertical slice of through the acoustic

Conclusions

The results of the seismic interpretation showed more complex-structurally faulted reservoirs with new faults along the horizontal well paths that were not previously mapped. The reinterpretation of the project was critical to re-define the locations (figure 8a) for one vertical, one horizontal well and to geo-steer the drill bit to effectively reach the targets and either anticipate or avoid geohazards. Coherence and curvature were the best attributes to identify geohazards such as small faults, karsts and lithological thickness variations. Coherence extraction along the top Viola is useful to produce accurate time and depth maps away from well control (figure 8b). Identification of geohazards with multi-attributes display and neural network prediction reduced the risk/cost of the project by drilling in the right place. Based on the economic analysis, it was noted that it helped to save $2.4 million.

Acknowledgements

Thanks to Pathfinder Exploration, LLC for providing us the 3-D seismic surveys and the well data for our research and for this publication. We also would like to thank the kind assistance of Sumit Verma, graduate student. Thanks to the University of Oklahoma and the Attribute Assisted Seismic Processing and Interpretation consortium for allowing us to use the software to complete this abstract.

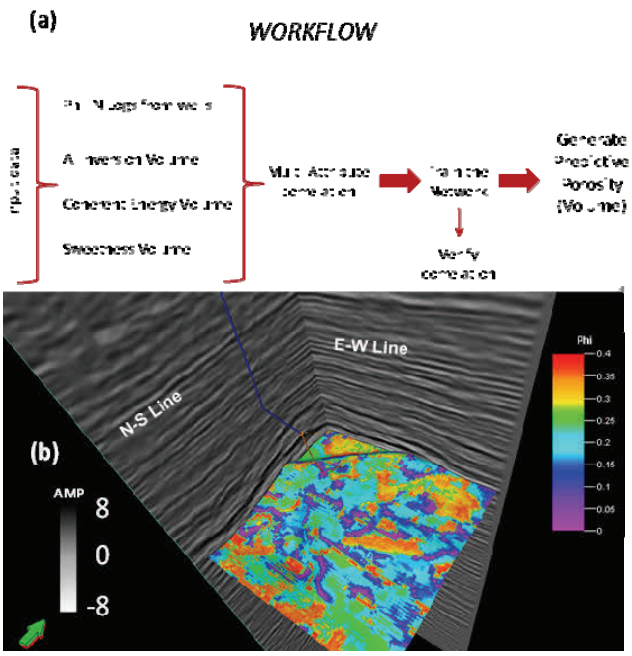


Figure 7: (a) Neural network workflow, (b) 3-D view of horizon slice along the top Viola through the predicted porosity volume.

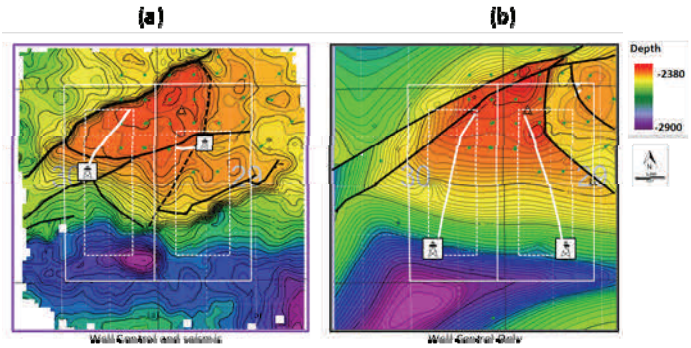


Figure 8: (a) Time-structure map of Viola horizon with the interpreted faults and new well locations, (b) depth-structure map of Viola with well control interpretation and the old well locations.

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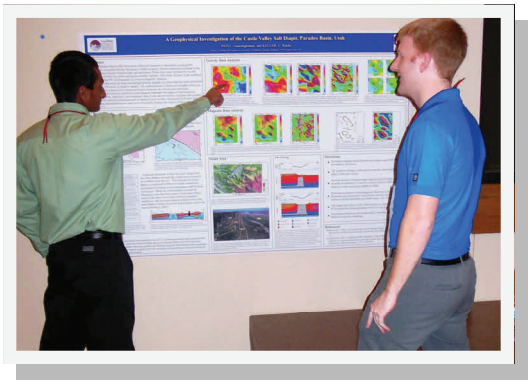
Student yearbook

2012 Holiday Mixer

2012 Outstanding Senior Award Ceremony
MCEE Outstanding Senior, Shelley Wernette

2013 APPG/SEG Spring Break Student Expo



2013 Back-to-School Mixer
Clear Bay Café, Lake Thunderbird

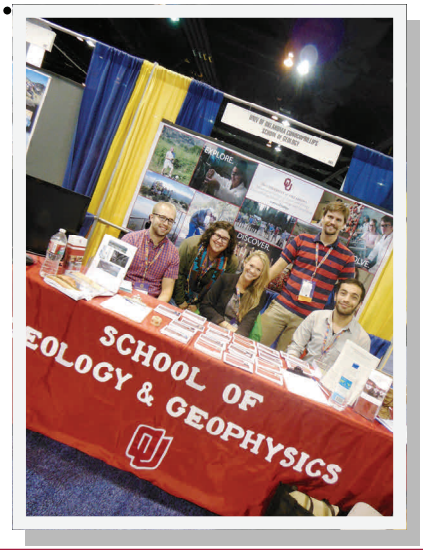
2013 Spring Awards Picnic
Lions Park in Norman, Okla.

2013 University of Oklahoma Homecoming

2013 AAPG Annual Convention

2013 SEG Annual Convention

2013 GSA Annual Convention



In memory...

John "Tim" Kwiatkowski

1965 - 2013


"No good deed goes unpunished" – J. Tim Kwiatkowski 11/27/1965-8/16/2013

After graduating in 1998 with his doctorate from the University of Oklahoma, John Tim Kwiatkowski began working for the Center for the Prediction of Storms, managing their supercomputers. A colleague, Brandon George, who later became the coordinator for the CAPS supercomputers, says, "He was then, and still is to this day, one of the most intelligent people I know. I don't think there is anything he could not accomplish when he has put his mind to it."

In December 2000, Kwiatkowski began working for the Shell Crustal Imaging Facility as systems administrator. Early in his career, he demonstrated a talent for translating scientific concepts into mathematical models for computer implementation. Kwiatkowski began helping graduate students and senior scientists with their software projects, helping to optimize routines and to add user interfaces. Eventually, he was instrumental in releasing Fusion Geophysical's spectral decomposition software to the geophysical world.

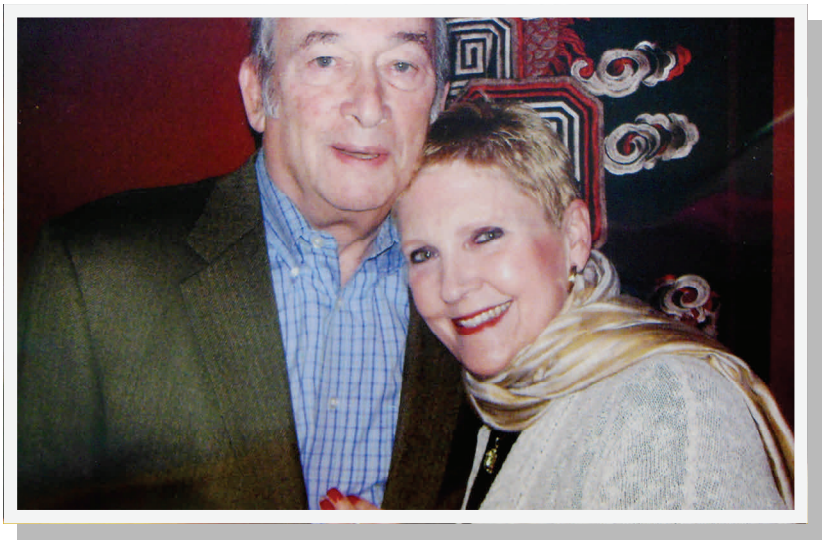
During his time with SCIF, Kwiatkowski and others on campus had the idea of a supercomputing center. As a result of their discussions, Henry Neeman, who holds a doctorate in computer science, was hired and the OU Supercomputing Center for Education and Research was off and running, with Kwiatkowski serving on the Board of Advisors.
Kwiatkowski was a dedicated scientist to the very end. He reviewed his last paper for the SEG two weeks before his death, sat on his last thesis defense as a committee member a week later and made a software release three days before his passing.

He donated his remains to OU Medical Center for cancer research. So, in true Kwiatkowski form, he continues to do science even now.

Kwiatkowski filled at least four roles at the university: mentor to students with technical applications, guru/teacher of computational geophysics, research scientist and lead programmer/problem solver/system administrator. Each of Kwiatkowski's accomplishments was made while assisting his colleagues with whatever geophysical or computer difficulty that arose in the course of a day. Computer crashes and network outages seemed no more troublesome than a cloud momentarily blocking the sun.

Most students thought he was brilliant, and therefore, at a level that they could never attain. He was indeed very smart, but his strongest suits were persistence and patience, whether unraveling a piece of "spaghetti code" or reconstructing hopelessly scrambled seismic geometries, often taking days of hard work. When it came to coding, Kwiatkowski was a perfectionist. While his office was a mess, his software products were pristine and perfectly organized. He serves as a role model for

Contributions may be made in Kwiatkowski's memory to the Wick Cary Crustal Imaging Facility Fund #42481, c/o The University of Oklahoma Foundation Inc., 100 Timberdell Road, Norman, OK 73019-0685.



Linda Gay Slatt

1944 - 2013

Linda Gay was a wonderful, loving, sharing, giving and elegant woman, mother and wife. She prided herself in her independence, even up to the time she left her earthly body. There never was a person that Linda Gay would meet without walking away with a new, mutual friend. One of her greatest joys was traveling, and she touched the lives and hearts of many people both at home and abroad. Another of her passions was reading, and she would often devour a book at a single sitting. Wherever she lived, she always took her extensive library of what she called her 'friends'. She had many accomplishments, including raising her own family as well as two stepsons, zoo docent, Realtor, shop owner, and her proudest time while in Norman, as elected president of the OU Faculty Spouse Association. She will be missed by many, many friends and relatives.

She is survived by her husband, Roger M. Slatt; son, Clifford James and wife Kalette; daughter, Lacretia Roland; granddaughters: Kourtlyn James, Whitney Smith and husband Rusty, Tyler Bosman and husband Zoren, Shayla Samarron and husband Frank; grandsons: Copeland and Cutter James; great granddaughters: Austin, Abigail and Miracle: great grandsons; Dorrian and Caleb; Brother, Bennie Pickrell and wife Linda; stepsons, Thomas Slatt and Andrew Slatt; step grandson Alexander Slatt.

She was preceded in death by her father, Sonny Pickrell; mother, Ferol Jones; daughter, Crystal James; brother, Mickey Pickrell; sister, Virgie Thomas.

Memorial donations may be given to The Linda Gay and Roger M. Slatt Endowed Graduate Student Support Fund #42687. The purpose of this fund is to provide scholarship and related support for graduate student research, teaching assistantships or related support of graduate student activities.

–Credit: Roger M. Slatt

In Memory of Our Alumni Gone Too Soon

Reported as of August 2013

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Mr. Gene C. Aldridge
Mr. James H. Ballard
Dr. John W. Bartley
Mr. Phillip R. Becker
Mr. Don E. Brown
Mr. Bruce M. Burum
Mr. James L. Cannon
Mr. Cecil H. Carson, Jr.
Mr. Robert L. Cash
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Mrs. Barbara M. Creager
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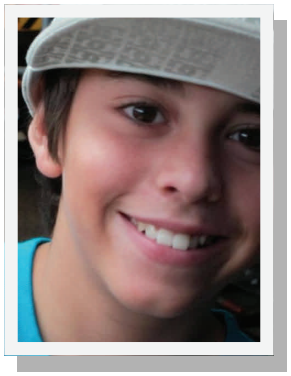

Mason Ryan Wight

Son of alumnus Doug Wight

2001—2013

"A young geologist at heart"

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