Oklahoma Geology Notes

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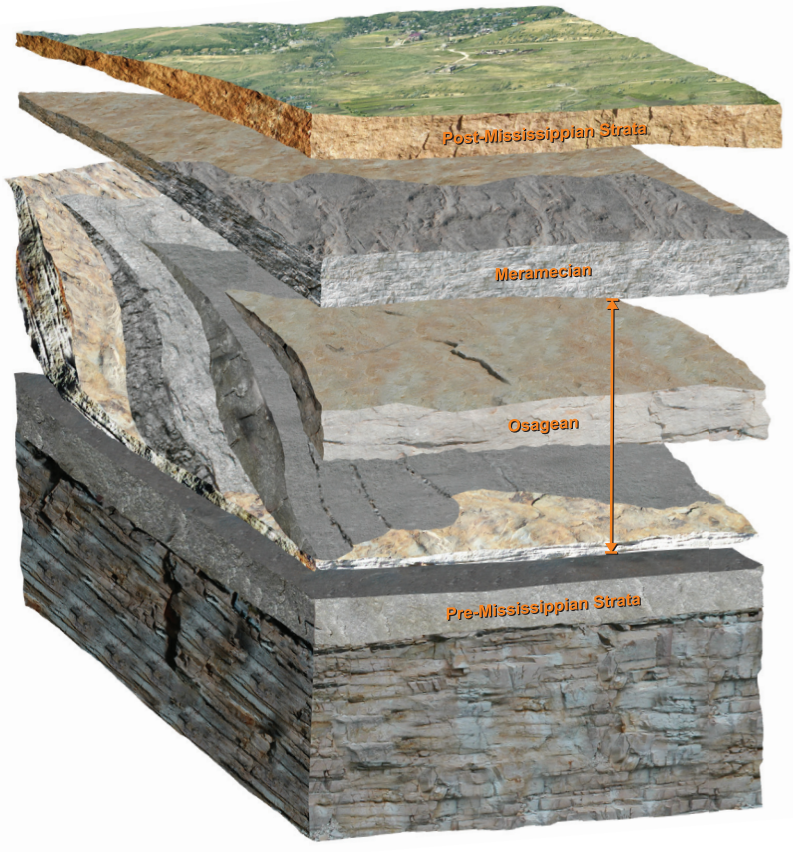
The University of Oklahoma MEWBOURNE COLLEGE OF EARTH & ENERGY

Mississippian Play Workshop a Sellout!

G. Randy Keller, Oklahoma State Geologist and Dan Boyd, OGS Geologist

One of the Oklahoma Geological Survey's primary missions is the dissemination of information necessary to assist operators in the development of the State's oil and natural gas resources. Towards that end the Survey hosted a workshop dedicated to one of the most actively sought reservoirs in Oklahoma. The Mississippian Play Workshop that was held on May 18th was bittersweet for Survey staff. Although we obviously selected a topic of tremendous interest to our audience, we unfortunately could not begin to accommodate the number of people that wanted to attend this workshop. On the plus side, ***an audience of approximately 300 was able to attend the workshop, which received excellent reviews for its fresh and varied look at the Mississippian Play.***



Due to the overwhelming popularity of this workshop, the Survey is offering it again on August 2nd. This has been made possible through the kindness and assistance of Kurt Rottmann, the workshop's technical coordinator, and several other speakers from the May workshop who graciously committed to present their material for a second time.

The Mississippian of northern Oklahoma, often called the Mississippi Lime, has long been an important producing horizon. In some areas, such as the Sooner Trend, which is located on the shelf of the Anadarko Basin in north-central Oklahoma, it has been the primary producing formation since the 1960's. However, in most other areas it has been regarded as little more than a convenient 'bail out' zone for wells that were unproductive in their primary objective. The fact that it was almost always oil-saturated gave it the ability to produce almost anywhere. Unfortunately, its low matrix permeability meant that while it could usually produce enough to pay for the completion, this was rarely sufficient to pay for an entire well.

Usually appearing on well logs as a massive limestone, in places the Mississippian contains zones that are siliceous. The most prolific of these cherty intervals, which often have excellent reservoir properties, occurs at the very top of the interval and is usually referred to as the Mississippi Chat. It was this facies that was developed first. The limestone beneath consists of alternating porous and impermeable strata that are often barren. Difficulties in correlating various facies within the limestone made them appear in an erratic and seemingly random pattern. This lead to a fundamental misunderstanding of the reservoir's potential, which in turn has lead to bypassed reserves.

Operators today, armed with modern horizontal drilling and completion techniques and the benefit of high crude oil prices, have been able to breathe new life into this reservoir's development. Horizontal wells are ideally suited to Mississippian reservoirs that are usually

Continued on pg. 2

Mississippian Play Workshop, continued from p. 1

characterized by low matrix porosity and permeability that are enhanced by the intermittent presence of natural fracture systems. Unlike a vertical well, they provide thousands of feet of wellbore exposure to the formation which can be enhanced through multi-stage acid-fracture stimulations. They also make it possible to intercept multiple natural fracture sets. However, horizontal wells are also expensive, making the vertical placement and orientation of the lateral critical to economic success. For this reason consistent correlation of productive intervals, an understanding of their depositional/diagenetic history, and an awareness of the factors that affect their production characteristics is absolutely vital.

Rottmann, a consulting geologist in Oklahoma, recognized the need to understand the many complexities associated with Mississippian reservoirs. Towards this end Kurt *(shown below)* performed a comprehensive geological analysis of the interval in which he has used thousands of well logs to unravel its stratigraphic architecture and set up a practical, consistent correlation scheme for all of North Central Oklahoma. This has made it possible to better understand the subsurface geometry of productive facies contained within the Mississippian interval and develop a methodology by which it is possible to more reliably predict their occurrence.

Rottmann and co-presenters showed how Mississippian reservoirs behave in detail through horizontal well histories and field studies. These field studies highlighted porosity types, fracturing, completion techniques, reservoir drainage, in-fill drilling potential, and the production characteristics of various reservoir systems. These presentations were enhanced by others that outlined seismic, petrophysical, drilling and completion techniques that have been shown to be effective in evaluating and exploiting this stratigraphic interval. Cores of the Mississippian were on display to provide 'ground-truth' examples for many of the reservoir types discussed. Technical posters featuring the Mississippian Play were also featured.

The presentation program for Mississippian Play Workshop is shown below:

- **Mississippian Regional Setting and Overview**; *Kurt Rottmann, Consultant*
- **Stratigraphic Architecture of the Kinderhookian to Meramecian Series**; *Kurt Rottmann*
- **Seismic Expression of Mississippian Plays**; *Kurt Marfurt, University of Oklahoma Mewbourne College of Earth & Energy ConocoPhillips School of Geology & Geophysics*
- **Initial Results of a Six Horizontal Well Drilling Program Targeting Mississippi (Osagean) Reservoirs in NE Oklahoma**; *Shane Matson, Spyglass Energy Group, LLC*
- **Petrophysical Evaluation and Identifying Natural Fractures from Conventional Wireline Logs**; *Mark Przywara, NuTech Energy*
- **Borehole Image Interpretation Techniques and Examples: Mississippian of Northeast Oklahoma**; *Greg Flournoy, Schlumberger*
- **Historical Overview of Mississippian Production in NE Oklahoma**; *Charles Wickstrom, Spyglass Energy Group, LLC*
- **Field Examples of Osagean/Meramecian Reservoir Systems**; *Kurt Rottmann*
- **Field Examples of Fracturing and Drainage**; *Kurt Rottmann*

In This Issue. . .

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Oklahoma Petroleum Information Center (OPIC)—Lots of rocks, data, activity, and improvements

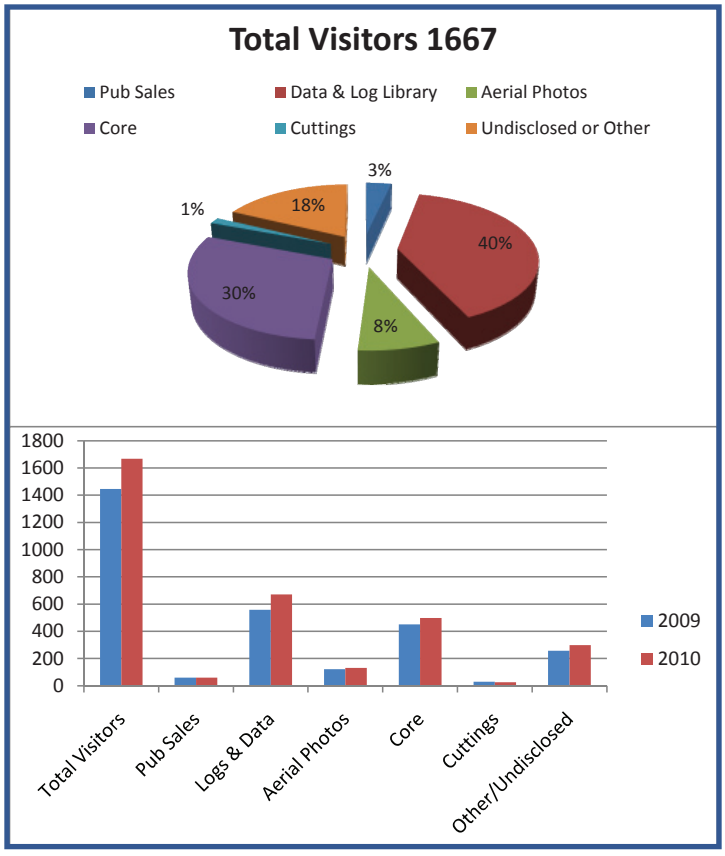
G. Randy Keller, Oklahoma State Geologist and Gene Kullmann, OPIC Facility Manager

The ***Oklahoma Petroleum Information Center (OPIC)*** has its roots in the Oklahoma Geological Survey core and sample library that was established in 1937. With the acquisition of a large warehouse facility (192,000 sq ft) to hold the massive collections of physical samples and documents, OPIC was opened in 2002. However, it was mid-2005 before all the physical samples were sorted and shelved. Today, once a customer identifies a specific box of core that is of interest, turnaround time on pulling cores and cuttings will vary dependent upon such factors as volume of prior requests, availability of viewing tables, etc., but we aim for same-day service whenever possible. ***OPIC now houses over 400,000 boxes of core and cuttings from Oklahoma and over 30 other states and thus preserves samples acquired from wells drilled as far back as the 1920s for future study and analysis***. Today, the building also houses the OGS publication sales office and an extensive library of petroleum data for Oklahoma in paper form. These materials are being scanned as fast as resources allow.

The creation of OPIC was made possible by a gift from BP, a global oil and gas production and refining company, when they donated a collection of core samples from oil and gas wells to the University of Oklahoma valued at more than $2.5 million. The gift includes over 100,000 boxes of core samples and rock cuttings totaling some 300,000 feet or around 57 miles of cores weighing in at some six million pounds. Also included were core analysis equipment and storage system components from BP's core facility in Tulsa. Along with the core material, BP provided a $3 million donation to help with the huge task of getting the facility ready for regular use by the public.

In addition to being an invaluable source of information for those engaged in hydrocarbon exploration and production, OPIC's holdings are used in many other ways. The Oklahoma Geological Survey and U.S. Geological Survey maps and publications available at OPIC often are used by hikers, campers, hunters, fishermen, school and scout groups, and teachers. In addition, ***public officials planning highways and facilities and those engaged in urban planning, water projects, alternative energy projects and other important activities necessary for economic development of Oklahoma often make use of OPIC***. In addition, new information can be gleaned from the cores and samples as evidenced by the request of a local museum to use OPIC material to study pollen in core. The ***historical collection of aerial photographs also has many uses such as environmental studies, studies of natural drainage patterns, and investigations of boundary lines***.

Thanks to improvements that have primarily been funded by Devon Energy, 2010 saw a significant increase in usage of the facility that is continuing into 2011.



Overall visitors show a 13% increase between 2009 and 2010.

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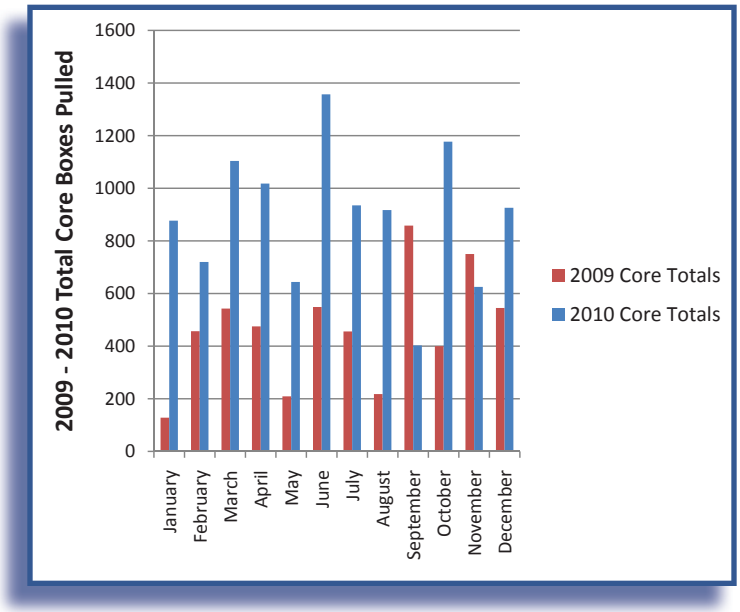
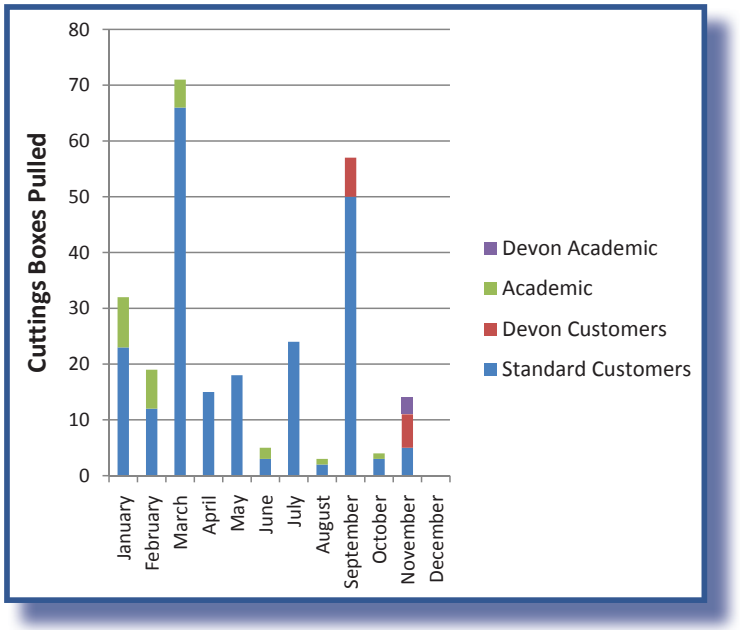
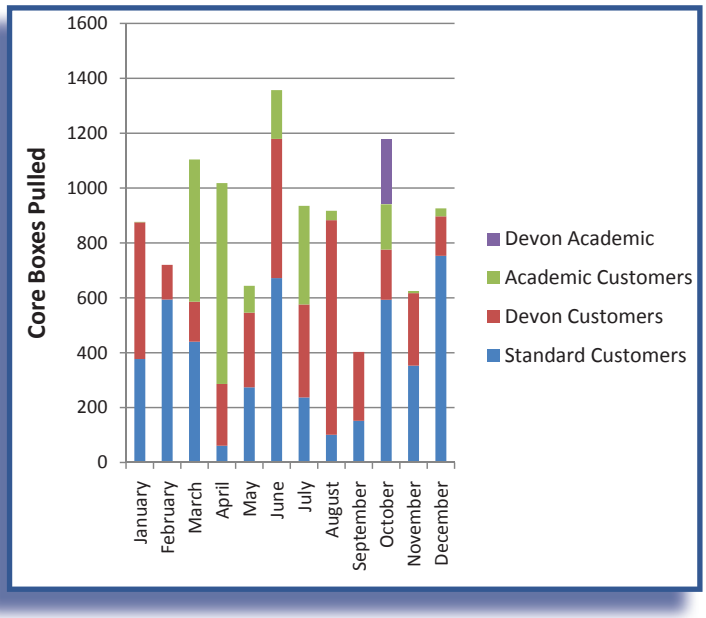
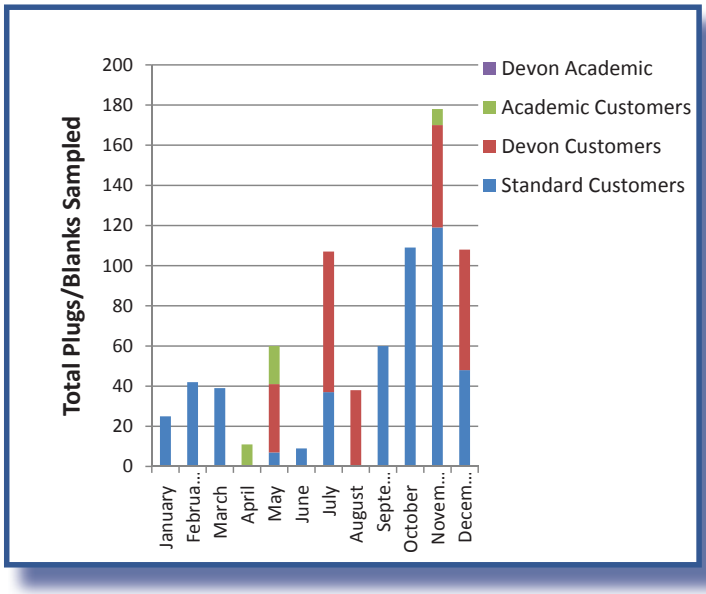


In 2009, an average of 466 boxes of core/month were pulled from the shelving for examination. This number was 892 boxes/month in 2010, which equals a 91.4% increase. The 2010 breakdown by type of customer is shown below.

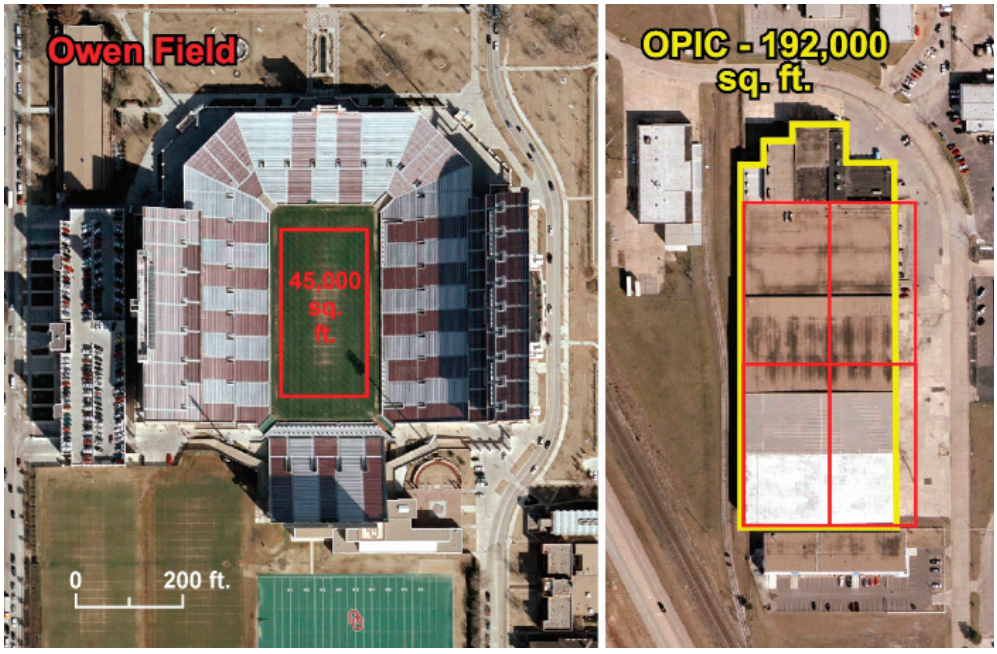


In addition to cores, there is an extensive collection of cuttings recovered during the drilling. Although not as informative as cores, these samples are regularly viewed by customers. OPIC also has variety of equipment for cutting and coring to extract small samples from cores.





Boxes of core and files of paper records.



OPIC's roof area is larger than the playing of <u>four</u> Owen Fields!

OPIC holdings consist primarily of the following:

- More than **100 miles of core** from almost **10,000** Oklahoma wells as well as from **over 30 other states**. This collection consists of approximately **375,000 boxes of core material** and is valued at more than $3.5 million.
- **Samples from more than 50,000 wells**.
- Well logs, production reports, and other material vital to petroleum exploration and production. The *OGS Well Data Library* is the **State's official repository for full-scale (5 inches to 100 ft) paper logs** from more than 367,000 wells, with new logs added daily. Some of the logs also are available on microfiche. Also in the collection are **126,000 strip logs dating from the 1890s that have recently been digitized** as part of the *Energy Library On-Line* effort). In addition, the library maintains a hard copy of 1002A completion reports (accessible digitally at **http://welldata.oil-law.com** or at **http://www.occ.state.ok.us/**) **from 1904 to the 1990s**; two sets of scout tickets; completion cards for Oklahoma wells; and a hard copy of aerial photos dating from 1940-1960 that are filed by county, township and range.

Created by the Oklahoma Territorial Legislature in 1890, the University of Oklahoma is a doctoral degree-granting research university serving the educational, cultural, economic and health-care needs of the state, region and nation. The Norman campus serves as home to all of the university's academic programs except health-related fields. The OU Health Sciences Center, which is located in Oklahoma City, is one of only four comprehensive academic health centers in the nation with seven professional colleges. Both the Norman and Health Sciences Center colleges offer programs at the Schusterman Center, the site of OU-Tulsa. OU enrolls more than 30,000 students, has more than 2,400 full-time faculty members, and has 20 colleges offering 163 majors at the baccalaureate level, 166 majors at the master's level, 81 majors at the doctoral level, 27 majors at the doctoral professional level, and 26 graduate certificates. The university's annual operating budget is $1.5 billion. The University of Oklahoma is an equal opportunity institution.

New OGS Publication Available for Purchase

Our newest publication is here!

EP 10: Dot-to-Dot Earth Science Activities for Grades 1-6

by Jim Chaplin

is now available at a cost of $15.00 plus $3.00 shipping/handling.

If you would like a copy of this publication, please contact either Joyce or Sue in publications.

Questions?

Please contact

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Science Education and

Stan Krukowski, OGS Geologist

The Oklahoma Geological Survey (OGS) participated in **Earth Week** activities at the Oklahoma City Zoo (OCZ) in Oklahoma City on April 21. OGS was Station No. 14 at the Oklahoma City Zoo where Oklahoma 4th and 5th grade school children learned about the ***extraction, recovery, and restoration of earth resources through a hands-on exercise*** called **Birdseed Mining**. Geologists Stan Krukowski and Ken Luza conducted the exercise with the assistance of Sue Crites, OGS Public Relations Coordinator (and editor of the *Oklahoma Geology Notes*). Also in assistance were several members of the *Red Earth Desk and Derrick Club of Oklahoma City*. REDDC promotes the education and professional development of individuals employed in or affiliated with the petroleum, energy, and allied industries and to educate the general public about these industries. On alternate years, the Oklahoma City Desk and Derrick Club assists the OGS staff at ScienceFest.

ScienceFest is an annual Earth Week event at the OCZ and is a day of interactive science and environmental activities focusing on ***the conservation of natural resources and the use of alternative energies***. ScienceFest is designed to promote scientific diversity. Hands-on activity stations use geology, biology, biodiversity, physical science, health sciences, ecology, soil science, water chemistry, physics, and several others to teach the children how science impacts everyday life. Examples of alternative fueled vehicles are also on location for the students to view. The event provides opportunity for the students to be exposed to science in a fun and different setting.

Total attendance this year was **6,115**, broken down as follows: 4,886 4th and 5th grade students; 1,112 parent chaperones and teachers; and 117 bus drivers. School districts from across the state of Oklahoma were represented. Students participated in 23 different activity stations that explored many topics in the sciences.

Sponsors of ScienceFest 2011 were OG&E Energy Corp., Oklahoma Department of Commerce, and Oklahoma Department of Environmental Quality. Activity stations were manned by scientists, engineers, and technicians from many governmental agencies and non-governmental organizations. They hosted groups of students at their respective booths and presented instruction and information on specific scientific topics. Students were able to increase their knowledge while participating in stimulating scientific inquiry, which hopefully may lead to pursuing science and engineering as a career.

OGS conducted **Birdseed Mining** at its activity station, teaching students the importance of using Earth resources in a responsible manner. ScienceFest 2011 marks the Survey's 6th consecutive annual participation in the event conducting Birdseed Mining. ***OGS estimated that up from 620 to 700 students participated in the Birdseed Mining exercise***.

The principles of sustainable development in resource development and mining operations were emphasized, demonstrating the roles of all stakeholders, including miners, nearest neighbors, the environment, government regulators, non-government organizations, and consumers. The OGS station included poster displays of mining, reclamation activities, and consumers' demands for Earth resources. Many hundreds more students, teachers, and chaperones visited the poster display and exhibit.

Birdseed Mining is an activity that was modified from the *Adventures in Earth Science Education* compact disc, produced and dis-

Outreach at the Zoo...

tributed by Caterpillar Inc., and used at the OGS booth for the Earth Week activities. Appropriate mineral wealth was placed in a small pile of birdseed along with candy treats, in this case Skittles®, and a "googly" eye. Students were given the task of mining for candy (mineral resources) solely with a plastic spoon (their 'mining' tool, which students referred to as their 'steam shovel,' 'excavator,' or 'digging tool') without spilling birdseed from a 4-inch plate. Spilling birdseed meant that they went outside the mine permit area and so they consequently were shut down (a case of mineral trespass) by the mine inspector—finding a "googly" eye (a mine accident) had the same result. Students in either of the latter categories were given candy consolation prizes. At the end of the mining period (30 seconds) students could eat their excavated candy (consume the mineral resource) before reclamation, which consisted of restoring the birdseed to its original stockpile cone on the 4-inch plate. Students realized pretty quickly the difficult practice of supplying raw materials for manufacturing the goods they use on a daily basis; the value of mine-land reclamation; and the meaning of stewardship associated with the extractive industries. A question-and-answer period followed stressing the principles of sustainable development, the environment, and the role of recycling and reuse of valuable earth resources.

OGS Geologist Stan Krukowski explains mining safety equipment.

OGS Geologist Ken Luza quizes students regarding mine-land reclamation as part of the exercise.

OGS Quarterly Earthquake Report 2011 1st Quarter

Austin Holland, OGS Research Seismologist; Amie Gibson, OGS Research Scientist II

There were **298** earthquakes in Oklahoma in the first quarter of 2011 (Figure 1). The majority of these earthquakes occurred in the ongoing swarm in Oklahoma County, which experienced 122 earthquakes. Lincoln, Garvin, and Pottawatomie Counties also had significant numbers of earthquakes with 64, 47, and 26 respectively. There were 21 different Oklahoma counties that had earthquakes located within their boundaries in the 1st quarter of 2011. We continue to operate accelerometers provided by the United States Geological Survey (USGS) in Oklahoma County.

There were 14 earthquakes that were reported felt in the first quarter of 2011 (Table 1). The largest of these earthquakes include a magnitude 3.4 earthquake on January 15 at 5:51 AM CST in Oklahoma County, and a magnitude 3.4 earthquake in Okfuskee County on March 30 at 11:41 PM CDT. There were also felt earthquakes in Lincoln and Pottawatomie Counties.

We have done countless interviews over throughout the 1st quarter of 2011. Many were in response to the magnitude 9 earthquake on March 11 in Japan. Some interviews were in response to the continued earthquake activity in Oklahoma County and around the state. The Leonard Observatory conducted two tours of the facilities and provided information about earthquakes in Oklahoma. The Leonard Observatory also had three community services workers helping out. We are pleased to welcome a new volunteer coordinator at the Observatory, Betty Morris, who recently began donating her time to help at this facility.

The Oklahoma Geological Survey continues to include data from the NSF Earthscope Transportable Array (TA) stations located within or near the Oklahoma. We also began the process of

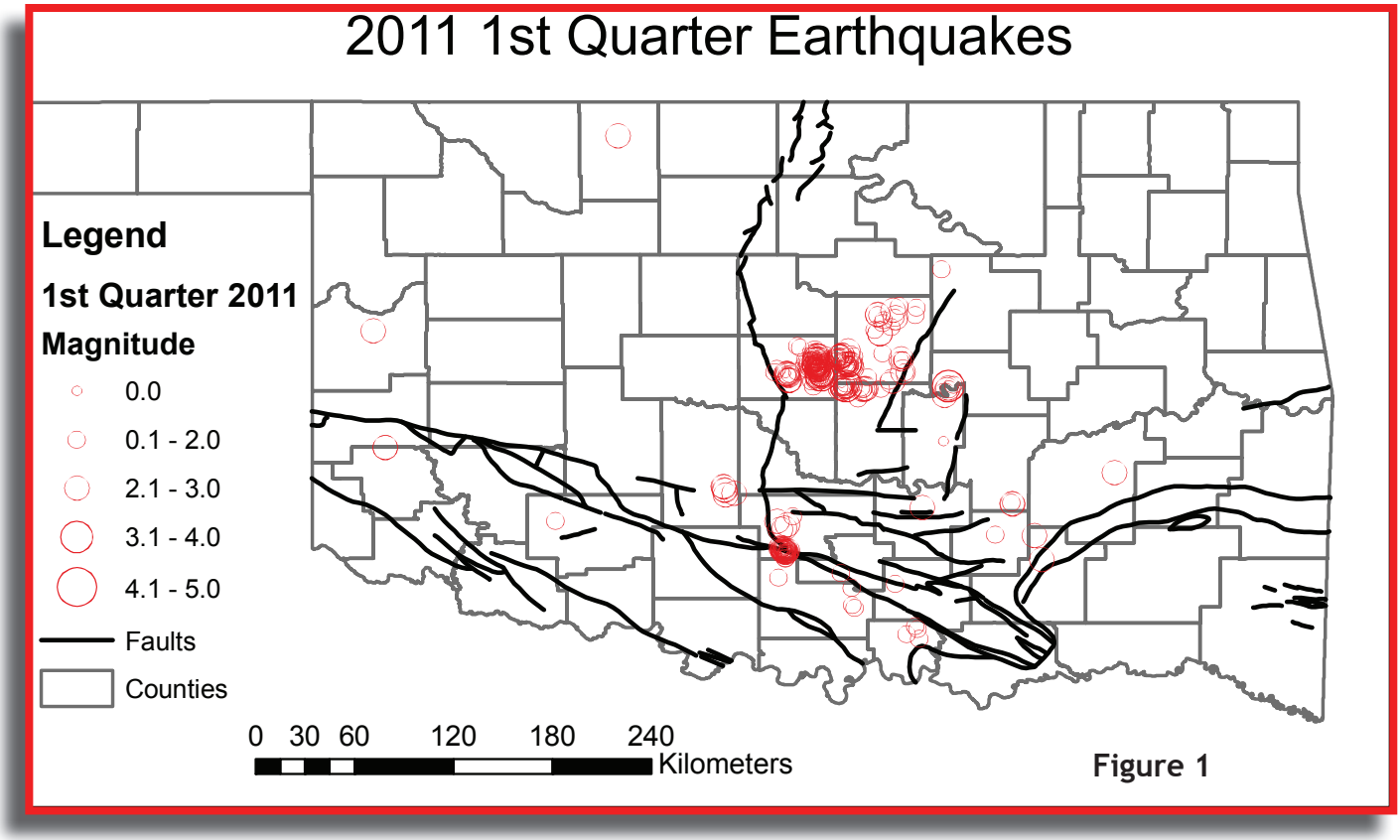

Figure 1

adopting four TA stations. The TA has already begun to remove stations out of the western portion of Oklahoma and surrounding states. This data has already provided many new capabilities and insights into understanding Oklahoma seismicity. We will continue to gain insight from this incredible dataset for years to come.

Recent work at the OGS has shown that the rate of earthquakes in the state has increased remarkably since 2009. We continue to examine what could possibly be causing such a noticeable increase. In addition we have determined many high quality focal mechanisms for earthquakes while the TA has been in Oklahoma. This has allowed us to model the stress field for Oklahoma. This work shows that most of Oklahoma is experiencing generally east-west compression and the earthquakes are in response to this compression.

Download 2011 1st Quarter Earthquake File (CSV): **http://www.okgeosurvey1.gov/media/quarterlies/2011_qt1.csv**

We encourage you to visit the Leonard Observatory website where we have information on recent earthquakes in Oklahoma and around the Earth: **http://www.okgeosurvey1.gov/**

TABLE 1

Origin Time (UTC)	Longitude	Latitude	Depth (km)	Magnitude		Modified Mercalli Intensity	County
					Type		
1/1/11 18:52	-96.9161	35.8372	3.2	2.9	Mc	III	Lincoln
1/4/11 18:31	-97.2381	35.5554	3.1	3	Mc	III	Oklahoma
1/6/11 6:52	-97.2775	35.5685	3.2	2.8	Mc	II	Oklahoma
1/7/11 5:11	-96.9827	35.4341	3.2	2.5	Mc	II	Pottawatomie
1/11/11 22:41	-96.9161	35.8402	5	2.6	Mc	II	Lincoln
1/12/11 17:20	-97.22	35.511	5.7	2.2	Mc	II	Oklahoma
1/12/11 21:12	-97.2223	35.5058	3.1	2.6	Mc	IV	Oklahoma
1/15/11 10:51	-97.221	35.5114	4.2	3.4	mbLg	III	Oklahoma
1/19/11 3:53	-97.1117	35.6211	5	2.8	Mc	IV	Lincoln
2/4/11 2:06	-97.4018	35.4801	5	2.6	Mc	III	Oklahoma
2/4/11 7:28	-97.3972	35.483	5	2.4	Mc	III	Oklahoma
2/4/11 19:49	-97.2344	35.6162	5	1.9	Mc	III	Oklahoma
3/11/11 10:56	-97.0872	35.4502	5	3.2	mbLg	III	Pottawatomie
3/31/11 5:41	-96.5272	35.4512	5	3.4	mbLg	II	Okfuskee

Geo-Archaeology Fieldtrip to

Neil Suneson, OGS Geologist

Figure 1. ANTH5933 (Advanced Lithic Technology) students examining basal Antlers Sandstone. Some clasts appear to have come from a great distance; other clasts appear to be locally derived, but no systematic study has been done on the provenance of the sediments here.

Dr. Don Wyckoff is the David Ross Boyd Professor of Anthropology at OU and a curator at the Sam Noble Oklahoma Museum of Natural History. One of his research interests is lithic technology, and for years he has tried to ***bridge the gap between what archaeologists know and how they talk about stone tools and what geologists know and how they talk about rocks***. **This communication and mutual understanding is critical for identifying the quarries ancient people used and the tools that came from them and thus, trade routes**.

Like most geologists, I have an interest in old things that are on the ground and thus, an (*albeit amateur*) interest in artifacts. I have served on thesis and dissertation committees that Don has chaired and that deal with the lithology and/or provenance of stone tools. In addition, I have shared my experience with the Bigfork Chert (Ordovician), Arkansas Novaculite (Devonian to lowermost Mississippian), Johns Valley Formation (Pennsylvanian) and Antlers Sandstone (Cretaceous), all of which provided raw lithic material for ancient peoples, with Don.

This winter I was invited to attend a field trip to southeastern Oklahoma that Don was running for his ANTH 5933 Advanced Lithic Technology course. The purpose was to expose the students to the problems archaeologists face 1) identifying the (geological) name of the rock ancient peoples used and 2) identifying the sources (*Quarries? Collecting sites?*) of tools collected at archaeological digs.

Our first stop on a perfect Saturday, February 19, was to visit a local rancher who had collected an enormous variety of artifacts near Farris, Oklahoma. He then took us to an old gravel quarry that exposed the very base of the Antlers Sandstone. Locally, underlying tilted Jackfork Group sandstone beds could be seen. The basal Antlers here is a poorly exposed cobble- and pebble-bearing gravel that appears to consist of two general varieties of clasts: 1) very rounded and very hard clasts (mostly quartzite or highly silica-cemented medium- to very fine grained sandstone) that are clearly not of local (i.e., Ouachita) derivation and may, in fact, have come from the Ogallala Formation), and 2) subangular clasts of sandstone derived from one of the Carboniferous turbidite units exposed in the Ouachitas. Some chert was also present. What was clear to everyone was the enormous amount of material available for ancient peoples to work, but the same material included a wide variety of lithologies (in detail). To this geologist it would be difficult, if not impossible, to indisputably tie stone artifacts to having come from the basal gravel of the Antlers Sandstone.

Following lunch in Antlers (the town, not the formation), we drove to the Potato Hills and the Cedar Creek outcrop. Here we examined in situ Bigfork Chert and Arkansas Novaculite. (*I think the archaeology students were more impressed with vertical —obviously having suffered mightily—beds than the chert beds themselves*.) We walked from the Ordovician to the base of the Mississippian (~100 million years) and talked about all the different lithologies that make up what geologists label as one formation. In other words, the Bigfork

Southeastern Oklahoma

Chert is not just chert; it contains a great deal of black shale and black siliceous shale. Of keen interest to the archaeology students was the variety of cherts present in the novaculite, especially the variety of colors, with a light greenish-blue being the most distinctive. The novaculite has been used for stone tools; it probably did not come from the Potato Hills where the novaculite is easily shattered, but probably did come from alluvial deposits downstream of outcrops.

Our last stop of the day was the famous Hairpin Curve locality of the Johns Valley Formation. I told the students that just about every geology field trip that visits the Ouachitas stop here, despite the highly degraded character of the outcrop. After a brief discussion of the origin of the Johns Valley, we scoured the slope along the road for chert; we found a few samples, but limestone is, by far, the most common "exotic" in this outcrop of Johns Valley. Don's research on archaeological sites in southeastern Oklahoma has convinced him that chert cobbles and boulders in the Johns Valley were major sources of raw material for tools. Unfortunately (perhaps), there probably is a wide variety of chert types (*Bigfork? Novaculite? Ozark? Arbuckle?*) in the Johns Valley, even *if* one could *positively* identify the source formation of the boulders.

Like any good geology field trip, this group of archaeology students ended up at Pete's Place in Krebs for dinner. And this trip, like any good geology field, once again proved the adage that, ***"a bad day in the field is better than a good day in the office,"*** and **this was a great day in the field**.

Figure 2. Outcrop of Arkansas Novaculite at Cedar Creek, Potato Hills. Dr. Don Wyckoff (blue hat, camera) discussing the character of the chert with students. Here, the novaculite is easily shattered but exhibits all the characteristics of a workable stone.

Got Prospects to Sell?

Join Us At The 4TH ANNUAL REAL DEAL MID-CONTINENT PROSPECT EXPO

October 1st - 4th, 2011

As an added bonus, this year's Expo is being held in conjunction with the *AAPG Mid-Continent Section Meeting* in Oklahoma City at the Cox Convention Center. We anticipate 900 - 1,000 attendees for this 4-day event. ~ Got Prospects to Sell? Pay only $250 for a Prospect Booth ~ Company Exhibitor Booth: $700

Registration forms, as well as a diagram of the Exhibition Hall Layout and Booth Locations, are located at: www.2011aapgmcsectionmeeting.org. Just click on the form tab for either prospect expo or exhibitors.

Exhibitor Booth: *Contact Dick Howell, 405/720-4328 or dick.howell@weatherford.com*

Prospect Booth: *Contact Michelle Hone, 405/236-8086, x10; email: ocgs.mhone@logixonline.com*

Remember — today's prospect may be tomorrow's play!

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