South Midcontinent Region
PTTC
Petroleum Technology Transfer Council
Regional Update
Third Publication, 2005

Candidate Selection for Horizontal Drilling with Case Studies in Osage and Tulsa Counties, Oklahoma

By Bob Westermark, Grand Directions, LLC

Over 95 attendees participated in this one-day workshop held in Norman, Oklahoma, which evolved from a DOE-sponsored horizontal waterflood project in Osage County. Grand Resources, Inc., in Tulsa manages the DOE Project. The horizontal drilling operations for this DOE project have been conducted by Grand Directions, LLC, a wholly-owned subsidiary of Grand Resources, Inc. Bob Westermark, president of Grand Directions, shared their experiences in conducting this project to date, emphasizing ***the need for team approach in planning a horizontal well project.***

Planning is a critical phase for drilling oil and gas wells, but this has become routine for most active operators. However, planning an economically successful horizontal well requires a strong technical team reviewing detailed aspects of geology and engineering that are not generally considered in drilling vertical wells. The workshop material reviewed the candidate selection process for drilling horizontal wells for improved primary and secondary recovery. Current available horizontal drilling options were discussed with the focus on medium- and short-radius techniques. In wrapping up the workshop, four other field case studies of horizontal wells in Tulsa and Osage Counties, Oklahoma, were summarized.

The workshop addressed the following questions:

How do I determine which of my reservoirs are valid horizontal well candidates?

Collect sufficient reservoir and production data to be able to build a computer model of the reservoir. Perform history matching to gain confidence on the simulation results. Predict the production effects of various horizontal completions options to determine the most reasonable approach to applying horizontal wells to accelerate reserve recovery.

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How do I choose which horizontal drilling system is appropriate for my reservoir?

An engineering assessment of the completion techniques necessary to economically recover the reserves will largely determine if the horizontal well can be an openhole completion or will require tubulars placed in the curve and/or in the horizontal sections. The critical issue is wellbore stability and the need for zonal isolation to construct a low-maintenance, long-life completion.

What are the costs associated with drilling horizontal wells using various drilling systems?

Based on studies of over 25,000 horizontal wells world wide, an expert has recognized key relationships between horizontal and vertical well costs.

- ❐ One third of horizontal wells are not economic successes.
- ❐ When the cost ratio for a proposed horizontal well approaches or exceeds 2.5 to 3.0 times the cost of a veritical well in the same field, the chances for an economic success are greatly reduced.

This means when evaluating the cost benefit of the horizontal candidate, if the proposed drilling and completion design costs are approaching 2.5 to 3.0 times the cost of a typically completed vertical well in the field, there is very little room for error and proceeding with assumptions rather than data can become very costly.

Do you need to drill a new well or can you use an existing well?

No, many techniques are available to use existing vertical wells and exit through the casing. Depending on the completion techniques required, the costs for using existing wells compared to new wells will generally favor existing well utilization. However, geologic considerations and current reservoir data collection opportunities must be weighed carefully with any potential cost savings.

Will an open hole provide a satisfactory completion technique?

This is determined by understanding the long-term borehole stability issue associated with the candidate reservoir. This issue is critical in determining the answer to openhole completions versus installing casing or liners in the curve or lateral sections.

How can your drilling and completion operation minimize formation damage?

Overbalanced, poorly-designed and maintained drilling fluids will cause excessive formation damage. The lower the bottom hole pressure (BHP) of the target reservoir, the more difficult it is to mediate any damage caused from the drilling and completion process.

Underbalanced drilling, when properly conducted, will help to minimize formation damage reducing or eliminating remedial action required to restore well bore productivity. The drilling fluids needed for underbalanced operations are determined by reservoir BHP. For low BHP situations, air or air mist/foam drilling may be required.

If you choose to drill underbalanced, can you safely drill with air?

Air drilling oil and gas wells has been an accepted industry practice for over 60 years. Grand Directions has been drilling with an air/foam-mist system for the last three years with no safety problems. However, many organizations/individuals are concerned with downhole and or surface fires, and therefore require additional procedures to mitigate this safety concern.

What kind of rig is necessary to drill horizontal wells?

When new wells are planned to be drilled horizontally, the drilling rig is usually employed to drill both the vertical and horizontal portions of the wells. However, depending on the equipment requirements for the curve and lateral sections, a smaller (less costly) workover rig may be moved in after the drilling rig has completed the vertical section.

When existing wells are to be used for horizontal completions, often a workover rig can be outfitted to handle the physical requirements of the operations less expensively than employing a drilling rig to do the work.

How do you determine and control the actual direction and location of the wellbore?

This is a two-pronged question:

1. How to determine the best direction to drill is determined by a thorough study of the geologic deposition, structural history and the reservoir fluid flow patterns resulting from withdrawal and injection activities. The size of the target and any spatial constraints associated with the target must be determined and specified in the well path plan.

2. How to control well path direction is the realm of the drilling operations. Many improvements in the directional surveying and tool-steering services have occurred in the past 15 years. Generally, the tighter the need for wellbore placement control, the more expensive the process.

Can you run open- and cased-hole logs in horizontal wells?

The idea of drilling horizontal into a known reservoir should produce openhole logs of consistent petrophysical measurements. This has not been the experience most people have had with regards to openhole logs from horizontal wells. When fracture identification and orientation with respect to the well bore are critical to the productivity of the horizontal well, openhole logs become keystone to the horizontal well project.

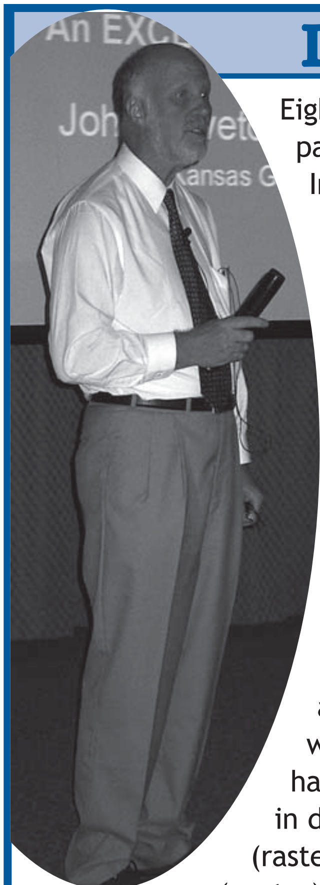
For example, understanding the injection profile of a horizontal injection well proved invaluable in reconfiguring the DOE pilot horizontal waterflood.

If necessary, how do you stimulate horizontal wells?

Many horizontal wells drilled today in the various “oil shale” plays in the USA require massive hydraulic fracture stimulation treatments, often costing as much as the horizontal section of the well. The wells must be drilled and completed with this in mind, as this is the technique that has evolved in a particular basin, providing the most economical cost-benefit ratios. Designing horizontal well fracture stimulation was beyond the scope of this workshop; therefore, it was not discussed.

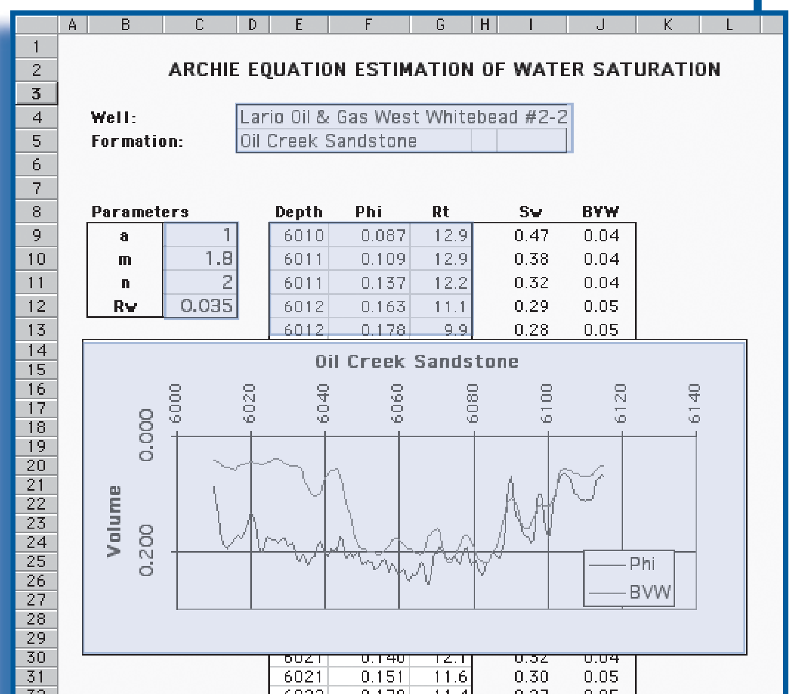
Log Interpretation Workshop a Popular Choice

By John Doveton, Kansas Geological Survey



Eighty-nine individuals participated in the "Log Interpretation Workshop" held at the Moore Norman Technology Center on September 21, 2005. This event was cosponsored by the Oklahoma Geological Survey and the South Midcontinent PTTC. The course presenter was John Doveton from the Kansas Geological Survey, who lectured from 9 am until 4 pm. The course began with an overview of the alternative sources of wireline log data, either as hard-copy paper records or in digital form as either scans (raster) or as numerical data (vector) on LAS files. The course presentation alternated between a Powerpoint sequence of slides keyed to the course manual interspersed with interactive demonstrations of spreadsheet functions for log analysis using Excel. Excel can be applied as a log-analysis method to both curve numbers transcribed by hand from paper copies or from LAS files read directly by Excel. A course manual was supplied to participants together with a CD-ROM containing the spreadsheet workbook, *"The Log Analysis Yellow Pages"* and three example LAS log data files. The *Yellow Pages* workbook is intended both to aid participants in their understanding of log analysis and also as simple freeware templates to apply to their own logs. The example LAS files contained logging data from reservoir sections of the Oil Creek Sandstone, Viola Limestone, and a Pennsylvanian oomoldic limestone.

The manual and its presentation provided participants with training in basic petrophysical concepts and a review of resistivity, SP, photoelectric index, neutron, density, and sonic porosity logs. Methods to estimate true volumetric porosity were described that accommodate changes in lithology as well as the effect on gas. The Archie equation was demonstrated with a variety of reservoir lithologies in the determination of water saturation. Extensive discussion was made of interpretation methods keyed to estimating water-cut of potential productive zones based on log indications of pore size from bulk volume water values. The course differed from a traditional log analysis course because of its emphasis on the use of spreadsheet software instead of chart book procedures and calculators. Almost all students and recent graduates of universities are already proficient in spreadsheet usage and so are well advanced on the learning curve to their application



to log interpretation. Professionals with many years of experience in industry may have had limited exposure to spreadsheet methods, but these skills can be acquired easily in courses at local colleges in continuing education programs. In summary, ***the course provided participants both a basic understanding of log analysis and the software methods appropriate to a PTTC target audience of small independents and individuals working within the energy industry***.

Booch Gas Play Workshop

December 1, 2005

Norman, Oklahoma

The Oklahoma Geological Survey, in cooperation with the South Midcontinent Region Petroleum Technology Transfer Council, will present a one-day workshop on the Booch gas play in southeastern Oklahoma. The workshop will be held at the Moore-Norman Technology Center, 4701 12th Ave., NW, in Norman, Oklahoma.

The workshop is designed to provide the participants with both a general and field-specific understanding of the Booch. Following a rigorous regional review is a detailed examination of three Booch gas fields that were chosen to highlight elements critical to Booch gas production. The geological analysis will be supplemented by a presentation of Booch drilling and completion practices from a guest speaker intimately familiar with Booch operations. A workshop manual and CD are included with the $50 registration. For further information, contact Michelle Summers at the Oklahoma Geological Survey, phone (405) 325-3031 or (800) 330-3996; fax 405-325-7069; e-mail: ogs@ou.edu; website: http://www.ogs.ou.edu/.

Dual Purpose Workshop Held in Arkansas

More than 50 participants met in Smackover, Arkansas, on August 10th to learn more about SPCC regulations, as well as artificial lift/downhole technology. This article is divided into two sections in order to provide you with a summary of both discussions.

SPCC: What the 2002 Amendments Mean to You as Oil and Gas Operators

By Michael Schmidt, Consultant, Regulatory Solutions

Speaking about rules is never interesting or exciting; but there are a number of state and federal rules with which producers must comply. SPCC is one of them. ***SPCC stands for Spill Prevention, Countermeasures and Control.*** It's one of those federal rules that has been around since 1973 but you rarely hear about until it matters most and you aren't prepared. The rule itself is found in Chapter 40 of the Code of Federal Regulations, Section 112, or 40 CFR 112 for short. It is administered and enforced by the EPA ***"to prevent the discharge of oil from non-transportation-related onshore and offshore facilities into or upon the Navigable Waters of the United States … to ensure effective response to a discharge of oil, and to ensure that proactive measures are used in response to an oil discharge."*** Since you produce oil, this rule directly affects you.

In August 2002, the EPA made substantial amendments to 40 CFR 112. ***The most important one requires you to have your SPCC Plans recertified by a professional engineer (PE) by February 18, 2006.*** The rule applies to any owner or operator of a non-transportation-related onshore or offshore, mobile or fixed, facility engaged in: drilling, production, gathering, storing, processing, refining, transferring, distributing, using, or consuming oil or oil products that could reasonably be expected to discharge oil in harmful quantities to the navigable waters of the U.S., and all related structures, piping, or equipment located in a single geographical oil or gas field.

Another major change involves defining a facility as starting at the wellhead, not at the tanks, and including all production-related vessels. The heater or separator is now part of that facility. So is the flow line from the wellhead to the tanks, the pumping unit, the chemical treatment drum. Every facility must have secondary containment and no containers 55 gallons or greater may be outside of that containment area. The rule is not applicable to containers less than 55 gallons (unless part of the production stream), or wastewater treatment facilities. Saltwater storage, injection and/or disposal facilities are not wastewater treatment facilities.

You say you don't have "navigable waters." That is an ongoing debate that the oil industry is sure to lose. As enacted and codified under this rule, ***"all waters used (past, present or future) in interstate or foreign commerce" are navigable waters.*** This means that if that pond or stream into which your facility could conceivably discharge has in the past, does now, or could ever in the future, support livestock that could potentially make it to the open market, that stream or pond is used in interstate commerce.

40 CFR 112 applies to any production facility with an aggregate storage capacity of 1,320 gallons or more and the potential to discharge oil. ***But what is oil?*** In addition to fats, oils and greases of various origin, EPA considers produced water to be oil for the purpose of this rule. They contend that you cannot separate all the "oil" from your produced water, no matter how hard you try. ***And what is a discharge?*** Discharge is defined as any spilling, leaking, pumping, pouring, emitting, emptying, or dumping of oil outside of primary containment. Luckily, not all leaks or spills are reportable discharges. The reporting threshhold is a one-time spill of 1,000 gallons or more, any spill to water, or any two discharges of 1 barrel or more within 12 calendar months.

Even an inactive facility, unless "permanently closed" (following specified guidelines) and having conspicuous signs posted on each container, falls under the rule.

How do you comply with 40 CFR 112?

1. Contact a professional engineer familiar with 40 CFR 112 to develop a site-specific Spill Plan for each facility and (re)certify it to current requirements. The PE must account for a worst-case scenario discharge; i.e., your largest storage tank ruptures while full during the heaviest rainstorm imaginable. He/She must establish inspection and emergency response procedures. The amendments allow the PE or his/her agent to do the site visit, resulting in a cost reduction for the Plan.

2. Implement the Spill Plan to ensure that the secondary containment complies with the PE's recommendations. To cover the precipitation factor for containment structures, some engineers use the largest tank plus 50%; some use 25% or X inches; others use the 24-hour, 25-year rain event; or they may offer you a variety of options from which to choose. But get your Plan done first, then build your containment structures according to the engineer's recommendation.

3. Sign each of your Spill Plans to signify that you will commit the necessary resources to clean up any discharge, you agree with each plan, and you will implement each plan.

4. Annually train all oil-handling personnel (pumpers mainly) in equipment operation and maintenance, pollution control laws, and reporting requirements. Keep training records. Place a copy of the Spill Plan at each facility.

5. After an initial inspection to activate the Spill Plan, inspect the facility each year in accordance with the PE's specification.

6. Attach to each Plan the emergency contact information for the environmental service firms, vacuum truck companies, heavy equipment (backhoe, dozer) companies, and roustabout crews you will call if you have a discharge.

7. Review your Plans for applicability every 5 years. Technical changes, such as adding or subtracting tanks or vessels,

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or changing their size, necessitate Plan recertification. Administrative changes, such as a pumper change, do not need to be recertified.

EPA Region 6, which includes Arkansas, Oklahoma, Texas, Louisiana, and New Mexico, has developed an expedited enforcement program for SPCC. The inspectors know what industry facilities should look like. They are not "out to get you" but are simply enforcing the rules. But accidents happen. ***What if you have a discharge?*** Implement your Spill Plan, clean up the spill, report details as required, and pay your fine, to spare yourself additional penalties. ***This will save you money in the long run.***

Artificial Lift—Downhole Technology

By Jane Weber, OGS Staff

The second part of the double-header program focused on artificial lift technology, a topic suggested by the operators themselves. Dwain Wilson, Oklahoma City Regional Manager for Weatherford's Completion and Production Systems, made the presentation, drawing on information taken from Weatherford's 3½-day training course on artificial lift.

The program began with an overview of artificial lift technology. That was followed by a more in-depth look at reciprocating rod lifts, the type used most often in south Arkansas. It is also the industry standard for applications on land.

Ninety percent of wells worldwide use some form of artificial lift. The six basic types are:

- ❒ Reciprocating rod lift—efficient, easily serviced, flexible, high salvage value for equipment
- ❒ Electric submersible pump—excellent for offshore
- ❒ Progressing cavity pump—handles deviated wellbores with minimal surface requirements
- ❒ Plunger lift—ideal for wells that load up with produced wellbore fluids, easily serviced, economic
- ❒ Gas lift—excellent for offshore
- ❒ Hydraulic lift—good for high-volume, high-depth environments

Wilson also pointed out some hybrid systems, which combine the strengths of different types to increase efficiency and improve economics.

The discussion of reciprocating rod lifts covered the overall design and operation of the technology, including both tubing pump and insert pump models. The speaker gave instructions in how to "read" API nomenclature to determine pump features or sucker rod dimensions. He addressed both the strengths and limitations of various sucker rods—continuous and coupled, metallic alloy and fiberglass.

Advantages and disadvantages of using sinker bars and rod guides were explained. ***Wilson said the most common reasons for pump failures are operational (e.g., bad seating nipple, loose tubing anchor), well condition (e.g., fluid pound, sand), or mechanical (e.g., split barrels, make-up torque) problems.*** Improper joint make-up is the leading cause of sucker rod failures. Time and money spent in optimizing pumping units to reduce failures will pay off in less than six months.

The presentation ended with a brief look at surface equipment: the traditional beam pumping unit; various API classified pumping units; and non-conventional pumping units, such as ultra-long-stroke, low-profile, and hydraulic.

CONFERENCE ANNOUNCEMENT

"Coalbed Methane and Gas Shales in the Southern Midcontinent" Conference

March 21, 2006

Coalbed methane (CBM) has been an important unconventional gas play in Oklahoma since 1988 with as many as 600 completions a year. The most successful CBM wells are where specialized completion techniques were applied with a knowledge of coal as a reservoir. The success of the Barnett Shale as a gas shale in the Fort Worth Basin in Texas has generated an interest in other potential gas shales (e.g., Woodford Shale, Caney Shale, and Fayetteville Shale) in the Southern Midcontinent.

Potential topics include geology, source-rock characterization, reservoir architecture, exploration concepts appropriate to the region, methodologies and techniques for improved recovery, case studies, and current activity related to coalbed methane and gas shales. Area studies will be confined to the Southern Midcontinent (Oklahoma and parts of surrounding states).

This conference will consist of 12 papers presented orally, 5 informal poster presentations, and 8 commercial exhibits; it will be attended by 150–200 participants. It is being organized by Brian J. Cardott of the Oklahoma Geological Survey.

For additional information, contact:

Brian J. Cardott
Oklahoma Geological Survey
100 East Boyd St., Room N-131
Norman, Oklahoma 73019

Phone, 405/325 3031 or 800/330-3996; fax, 405/325-7069 or e-mail: bcardott@ou.edu.

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Locating Cores and Cuttings for Oklahoma and Arkansas

By Jane Weber, OGS Staff

Cores and cuttings brought to the surface during a drilling operation are a valuable permanent resource for study of the earth and its processes. Such material is especially important in the exploration for, and development of, oil and natural gas prospects and evaluating petroleum fields and individual wells. While the largest collection of Oklahoma samples is at **OPIC** (Oklahoma Petroleum Information Center) in Norman, the **Well Sample Library** in Little Rock contains the most Arkansas samples. Drillhole material from these two states can also be found in other locations.

Additionally, various repositories define and catalog geological samples differently. The word ***"core"*** may apply to whole (full-diameter), slabbed or sidewall core or core plugs. ***"Cuttings"***, synonymous with core chips, remnants or pieces, may be washed or unwashed. Sometimes this term includes core plugs. Outcrop samples, thin sections (slides prepared for examining microscopic details of rocks), and paleontology/palynology/geochemistry samples are frequently maintained and counted as part of a *"core"* or *"well sample"* collection. Some states collect material not only from oil and gas test holes but also from industrial mineral, coal exploration, and water wells.

The following list points toward Oklahoma and Arkansas core-related material. The numbers are ever-changing and therefore approximate. They are given only to indicate the amount of possibly relevant material available at that site. Without close inspection of the data, it is not always clear what a given number represents. For example, from the same well, a repository may house 2 cored intervals, 4 intervals of well cuttings, and 1 thin section. This may be reported as 1 sample, 3 samples, 4 samples, or 7 samples, depending how that facility records their list of samples. All the repositories listed here include Lease/Well Name, Company/Operator, and Depth information but only some give specific Location information.

OPIC
2020 Industrial Boulevard
Norman, OK 73069
Contact: Gene Kullman, 405-360-2886

- 8976 OK cores, representing 4649 wells. List available at http://www.ogs.ou.edu/OPIC
- 50,000 OK cuttings, digitally catalogued (list available upon request). Additional samples, indexed on cards, are continually being digitized.
- Small number of boxed samples from AR, representing 51 locations. Type of sample (core, cuttings, outcrop…) not yet determined.

Norman F. Williams Well Sample Library
1911 South Thayer Street
Little Rock, AR 72202
Contact: Jack Stephenson, 501-324-9167

- 50 AR oil and gas cores, mainly from south Arkansas, and 1500 AR cores from mineral exploration tests in the Ozark and Ouachita Mountains
- 2500 AR cuttings from oil, gas, and water wells

USGS Core Research Center
Building 810
Denver Federal Center
Denver, CO
Contact: 303-202-4851

Indexed by state, all lists are available at http://geology.cr.usgs.gov/crc

- 44 OK cores
- 245 OK cuttings
- 2 AR cores

Bureau of Economic Geology (BEG)
Austin, TX

- All geological material stored at BEG's Austin, Houston, and Midland facilities is searchable by state and various other criteria at **http://begdb1.beg.utexas.edu/Igor**

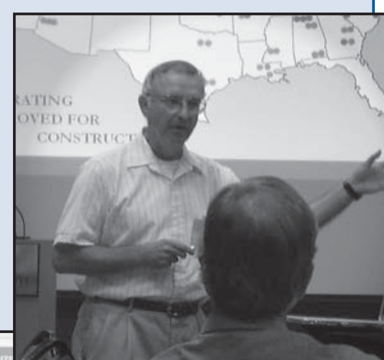
2005 AAPG Mid-Continent Section Meeting

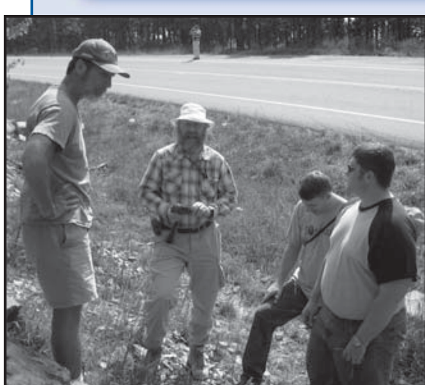
The Oklahoma Geological Survey (OGS) and South Midcontinent Region Petroleum Technology Transfer Council (SMR PTTC) exhibited at the 2005 AAPG (American Association of Petroleum Geologists) Mid-Continent Section Meeting, which was held on September 8th–13th in Oklahoma City by the Oklahoma City Geological Society (OCGS).

OGS retired geologist Jock Campbell produced a field trip covering the Arkoma Basin, Ouachita Uplift, Jackfork and Atoka Sandstones in various counties of eastern Oklahoma. Assisting him were co-leaders Neil Suneson and Galen Miller, OGS geologists; Dennis Kerr, University of Tulsa; and Ibrahim Cemen, Oklahoma State University. You can see from the photos below that a good time was had by all! *[Photos by participant Connie Knight, Admiral Bay (USA) Inc., and Galen Miller, OGS.]*

A fieldtrip entitled *"Surface Coal Mine to Determine Coal-Bed Methane Potential of the Coal, Okmulgee County, Oklahoma"*, was led by Sam Friedman, retired OGS geologist, on Sept. 13th.

Ken Luza, OGS geologist, taught a segment on earthquakes on Sept. 13th to a group of science teachers. Several other groups/organizations also gave presentations to this group of educators. *[Photos by Sue Crites, OGS staff.]*





Calendar of Upcoming Events

OCTOBER 20, 2005

2005 OKLAHOMA OIL AND GAS TRADE EXPO

State Fair Grounds
Oklahoma City, Oklahoma
Sponsored by Marginal Well Comm.

DECEMBER 1, 2005

"BOOCH GAS PLAY" WORKSHOP

Norman, Oklahoma
Oklahoma Geological Survey (OGS),
Petroleum Technology Transfer Council (PTTC)

MARCH 21, 2006

"COALBED METHANE AND GAS SHALES IN THE SOUTHERN MIDCONTINENT" CONFERENCE

Oklahoma City, Oklahoma
Oklahoma Geological Survey (OGS),
Petroleum Technology Transfer Council (PTTC)

UPCOMING EVENTS CONTACT INFORMATION:

Oklahoma Geological Survey, Michelle Summers, 405/325-3031; 800/330-3996; e-mail: ogs@ou.edu; website: http://www.ogs.ou.edu

The Oklahoma Commission on Marginally Producing Oil and Gas Wells (MWC): 405/604-0460 or 800/390-0460; website: www.marginalwells.com.

PETROLEUM TECHNOLOGY TRANSFER COUNCIL (PTTC)

South Midcontinent Region (SMR)

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<http://www.ogs.ou.edu>

Oklahoma Petroleum Information Center
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• *Well Data Services*
Phone: 405/360-2886 Fax: 405/366-2882
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Norman, OK 73069
e-mail: ogssales@ou.edu

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