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The Class Act

DOE's Field Demonstration and Best Practices Newsletter

CO_2 Enhanced Oil Recovery, Co-generation, Ethanol Production Linked

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The miscible CO_2 Enhanced Oil Recovery (EOR) demonstration in the Hall-Gurney field, Russell County, Kansas marks the first time that CO_2 from an ethanol plant will be used for EOR. The electrical co-generation, ethanol fuel production and carbon dioxide enhanced oil recovery project in central Kansas is a unique scalable model for linked energy systems. Waste heat from a 15-megawatt gas-fired turbine municipal generator provides heat inputs for a 25 million gallon per year ethanol plant that was very recently expanded to 40 million gallons per year. Carbon dioxide, a fermentation process byproduct of ethanol production, will be used in the DOE funded Class Revisit CO_2 miscible flood demonstration project. Efficiencies gained in byproduct utilization and energy use by linking traditional and alternative energy systems will enhance the economics of each while creating environmental benefits through geologic sequestration of CO_2.

The photo of the pumping unit demonstrates how close the oil field is to the ethanol plant and the CO_2 source.

The goal of the CO_2 miscible flood project is to demonstrate to Kansas's independent operators the technical feasibility of the CO_2 process in a major Kansas reservoir. The Hall-Gurney field, the largest Lansing-Kansas City oil field in Kansas is one of several CO_2 flood candidate fields in central Kansas. Partners in the project include the U. S. Department of Energy, MV Energy LLC, Kinder-Morgan CO_2, US Energy Partners LLC, the University of Kansas (Kansas Geological Survey and Tertiary Oil Recovery Project) and the Kansas Department of Commerce.

Background

The initial plan for the field demonstration for supplying CO_2 was to truck it 200 miles from Guymon, Oklahoma. The objective was to show independent operators that CO_2 flood could work as well in central Kansas as it does in west Texas with hopes that a CO_2 pipeline would eventually be funded and built. There have been no miscible CO_2 floods in Kansas primarily due to the distance to sources for CO_2. During the initial phase of the reservoir characterization plans were announced for the construction of the nearby ethanol plant and a new partnership was formed where the closer source of CO_2 could be utilized.

The majority of CO_2 from ethanol plants

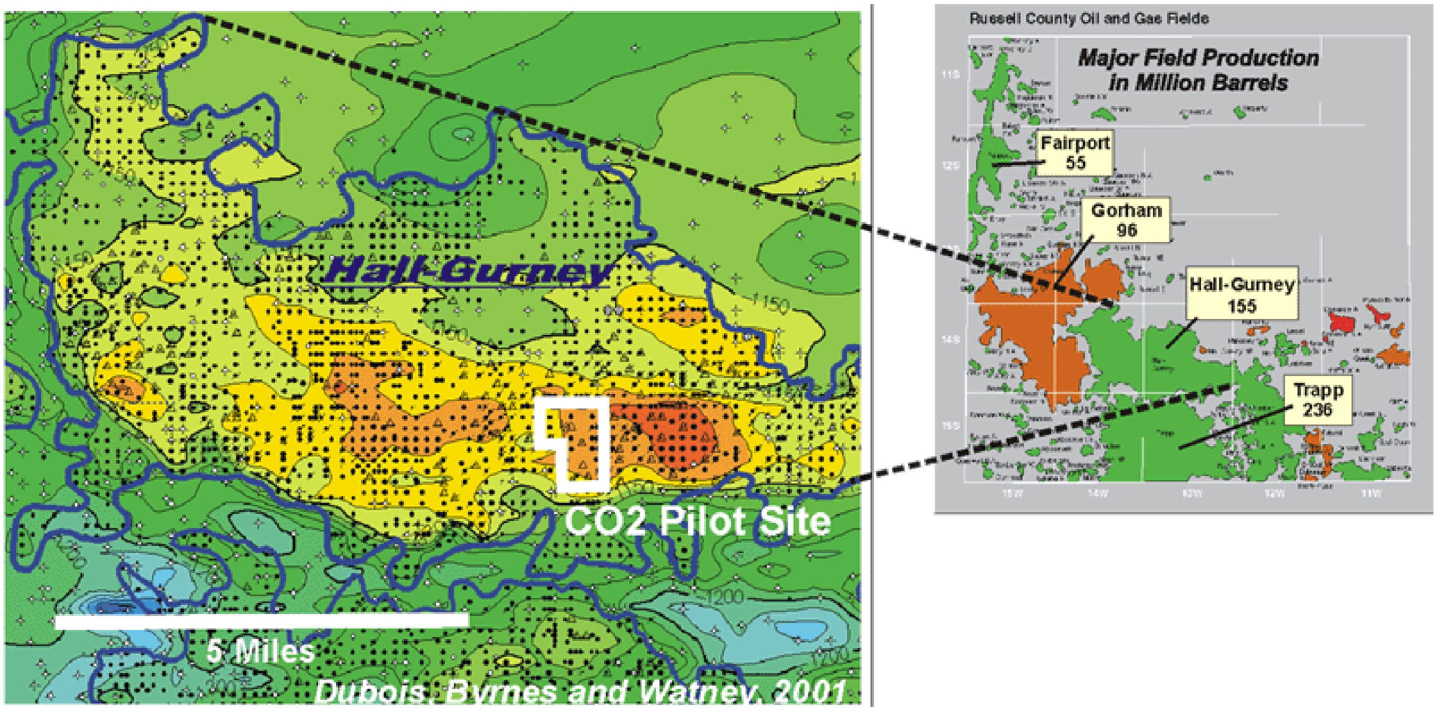

Figure 1. Prolific Lansing-Kansas City oil fields of Russell County are targets for CO_2 miscible EOR.

is vented and the balance is sold as liquid CO_2 for food processing and other industrial uses. Currently the U.S. ethanol industry is directly or indirectly, releasing five million tons of CO_2 per year to the atmosphere. Ethanol production and associated CO_2 emissions are projected to double by the year 2005 as ethanol replaces MTBE as a gasoline oxygenate. Responding to the Environmental Protection Agency's directive to eliminate MTBE by 2005, the ethanol industry is expanding current facilities and constructing new plants. Expansion of ethanol production means increased volumes of CO_2, most of which will be vented to the atmosphere.

CO_2 Miscible Flood Demonstration

Over the last century Kansas has produced over 6 billion barrels of oil, however, current production is only 1/3 of the rates in the 1950s. Many of the 6,000 fields in Kansas will be abandoned with substantial remaining oil left in place, unless new technology is introduced. CO_2 miscible flooding is the most promising oil recovery process for recovering additional oil from reservoirs in Kansas that have been waterflooded. The potential CO_2 miscible flooding in Kansas is estimated at 250-500 million barrels of oil, extending production an additional 7-14 years based on current production rates.

The target reservoir for the pilot demonstration is the Pennsylvanian Lansing-Kansas City group. The high porosity oomoldic grainstones of the Lansing-Kansas City (**Figure 1**) are widespread in central Kansas and offer the best choice to demonstrate the feasibility of CO_2 miscible flooding. Initial reservoir characterization of Hall-Gurney field indicates that the CO_2 enhanced oil recovery demonstration at the Colliver and Carter Lease would increase ultimate recovery 60 to 120MBO.

Linked Energy Systems

A combination of events in and near Russell, Kansas set in motion the Kansas model for Linked Energy Systems (**Figure 2**). An explosion at the diesel fired electrical plant in Russell in 2000 resulted in construction of a new co-generation electrical facility. In 2001 ICM, Inc. and U.S. Energy Partners built an ethanol plant in Russell. Waste heat from the municipal co-generation facility was contracted by the ethanol plant to use in production of ethanol. CO_2, a byproduct of ethanol production, was largely vented to the atmosphere. As a revenue enhancement, plans are to sell the majority of the CO_2 in the liquid food grade market, however, a portion of the CO_2 byproduct has been reserved for the CO_2 demonstration at nearby Hall Gurney field. 10-20% of CO_2 from the USEP ethanol plant will be trucked to the Colliver and Carter Lease at Hall-Gurney field for the pilot demonstration. To complete the linked energy system the agriculture industry provides the grain (milo), most of the raw material for the production of ethanol. Additional raw material is provided in the starch from an adjacent wheat gluten plant. Another byproduct of ethanol production is cattle feed (**Figure 2**). Based on

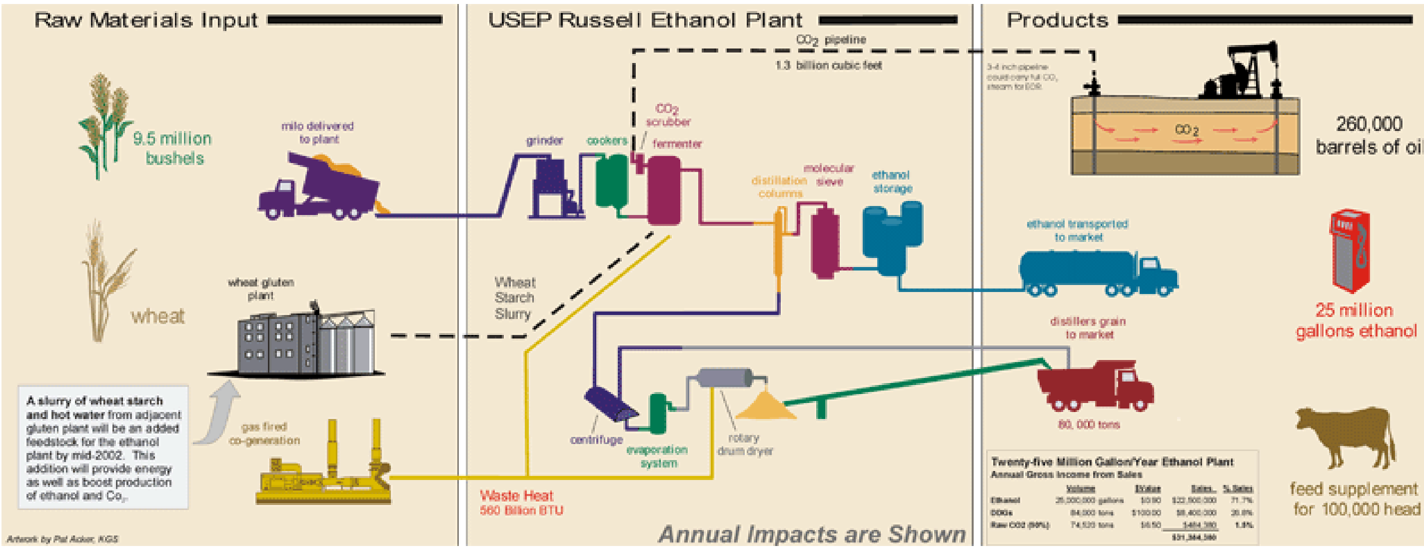

Figure 2. Linked systems could benefit six industries; agriculture, electrical generation, gluten and ethanol production, cattle feeding and CO_2 EOR.

information provided by the industries an input of one bushel of milo would produce $_2$.68 gallons of ethanol, 17.8 lbs of CO_2 and 18 lbs of cattle feed.

CO_2 Sequestration

An environmental benefit is gained by the use of CO_2 in the oil field demonstration. Previously USEP vented CO_2, either directly or indirectly, injection in Hall-Gurney field provides a mechanism for geologic sequestration of CO_2. CO_2 sequestration benefits are approximately equal to the net CO_2 utilization, or about 4.3 MCF per barrel of oil produced, which was derived in the DOE funded project. CO_2 emissions avoided by the co-generation and ethanol processes were calculated assuming that without the co-generation heat, the same amount of energy would have been generated by the use of natural gas.

Benefits

Statistical modeling for a 10-year period shows that economics for all linked industries would benefit from full utilization of the ethanol plant CO_2 stream (**Table 1**). Annually, 1.3 billion cubic feet of CO_2 injected in the Colliver and Carter lease would produce 260,000 barrels of oil. 25 million gallons of ethanol would be produced for use in fuels replacing MTBE. If the full CO_2 stream from the ethanol plant were utilized for enhanced oil recovery for a ten-year period the benefits from the links would realize \$88 million.

With the doubling of ethanol production nationwide by 2005 the potential oversupply of CO_2 must be addressed. The juxtaposition of major ethanol-CO_2 production with areas of miscible and immiscible CO_2 enhanced oil recovery prospects makes Kansas an excellent laboratory for CO_2 capture and geologic sequestration. As the co-generation and CO_2 EOR pilot gets underway in 2002 it will be the first time ever that these three energy systems have been linked. This study shows that a commercial project using the entire CO_2 stream from a 25 million-gallon per year ethanol plant may represent the minimum economic size for linked energy systems of this nature. EOR offers the expanding ethanol industry a potential market for CO_2 from new and larger facilities located close to EOR target reservoirs. The availability of CO_2 from ethanol plants offers the opportunity to expand oil production in the mid-continent, and may prevent the abandonment of many oil fields in Kansas with additional productive potential. **TCA**

Table 1. Economic Rates for a Ten-Year Period

Economic	\$8.8 million per year
Co-generation 560 BTU	\$1.7 million
CO_2 sales 1.3 BCF	\$1.3 million
EOR oil sales 260,000 bbl (\$20 bbl)	\$5.2 million
Agricultural cattle feed	\$0.6 million
Energy Gained	\$3.1 trillion BTU
CO_2 avoided/sequestered	160 thousand tons

ASP Pilot Lawrence Field, Illinois

Beverly Seyler, Illinois Geological Survey

Plains, Illinois, Inc. was funded in 2000 by the U.S. Department of Energy to evaluate alkaline-surfactant-polymer (ASP) flooding in the Cypress and Bridgeport reservoirs of Lawrence field in southeast Illinois (**Figure 3**). ASP enhanced oil recovery (EOR) has proven to be economic only as incremental recovery in mature waterflooded fields in Illinois. Lawrence field at 96 years old was reaching a "now or never point" in development with an estimated 40 to 70% of OOIP remaining in place. The ASP flood is designed to target the residual oil and maintain long-term cash flow for Lawrence field. Plains, Illinois partnered with the Illinois Geological Survey for all technology transfer activities.

Background

Demonstration of surfactant flooding in southern Illinois in the late 1960s, 70s and 80s demonstrated that residual oil could be produced by chemical flooding, but the cost was sufficiently high and projects were rarely economic. The objectives of the DOE Class Revisit project were to perform a comparison of EOR techniques, determine lower cost flood patterns, use lower-cost alkaline-surfactant-polymer chemicals, recommend field expansion, and test the efficiencies of flooding multiple reservoirs simultaneously. The pilot at Lawrence field was attractive, because the reserves target for the 60-acre EOR pilot at Lawrence field was 42,000 MBO.

The sandstones of the Pennsylvanian Bridgeport and Mississippian Cypress formations at Lawrence field were producing at less that a 3% oil cut, and were approaching their economic limit. The alkaline-surfactant-polymer flood utilizes reservoir characterization of the fluvial dominated deltaic sandstone reservoirs as a basic for the 60-acre pilot demonstration. Primary production from the Bridgeport and Cypress averages 10 to 20% OOIP. Waterflood production increases production on an average 20 to 40% of OOIP. Following waterflooding, southern Illinois fields average 40-70% residual oil, as a target for an effective, low-cost EOR technology.

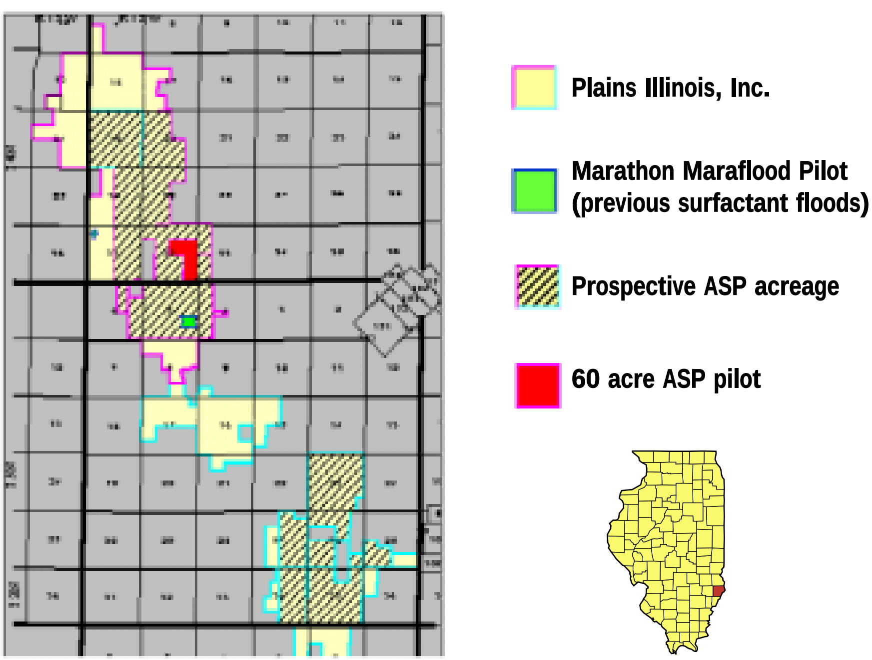

Figure 3. Lawrence Field showing the ASP pilot and Plains Illinois, Inc.'s holdings.

EOR Technologies

The results of reservoir characterization of Lawrence field, and a comparison of EOR techniques indicated that ASP flooding was the most applicable technology. CO2 is not miscible at the shallow depths of the Cypress and Bridgeport reservoirs (900 ft and 1600 ft) and is not readily available in southern Illinois. The high API oil gravity, low viscosity and the multiple beds rendered steamfloods inapplicable. Firefloods similarly were not applicable, because there is too little coke in the reservoir to propagate. Surfactant floods work in the Bridgeport and Cypress reservoirs but are expensive, ranging from $20 to $37 per barrel of oil recovered. Microbial enhanced recovery may offer viscosity reduction, and an increase or injectivity, general qualities of a surfactant, but have not been tested. New low-concentration injection techniques indicate that alkaline-surfactant-polymer flooding could be reduced to a cost of $4 to $8 per barrel of oil recovered. Based on a price of $20 per barrel of oil, modeling indicated that ASP would be economic at as low a 1% oil cut.

Lawrence Field

Parameters, which made ASP flooding possible at Lawrence field, included an abundant access to fresh water for flooding, and shallow thick net pay intervals. Based on an original estimate of 1 billion barrels OOIP, and cumulative production of 330 million barrels of oil, Lawrence field has 400 to 700 BO remaining-in-place. Two Maraflood surfactant flood projects (one in the Bridgeport

Figure 4. Core photo showing Cypress Sandstone interval 4(D). The Cypress Sandstone is the most porous and permable unit in Cypress. The core shows mottled iron staining. Rip-up clasts form permeablility barriers.

and one in the Cypress) proved that surfactant flooding was successful, if not economically feasible. Previous surfactant floods were terminated due to the high cost of chemicals and / or the low price of oil at the time. Because of the shallow production and available water, oil production at Lawrence field is economical at a very low oil cut, allowing a margin for investment in EOR technologies.

During the reservoir characterization phase of the project, six wells were drilled and cored. The data was used to map porosity and permeability zones, defining five units in the Cypress sandstone and dividing the Bridgeport into A (3 units), B (3 units) and D (2 units). The Cypress sandstone, characterized by fine scale bedding features and thin units of rip-up clasts, which form permeability barriers, is interpreted as tidal deposition. The Cypress sandstone interval 4D, shown in **Figure 4**, is the most porous and permeable unit in the Cypress.

The Bridgeport A unit is a channel sandstone overlain by bedded coal. A basal channel lag in the Bridgeport A is cemented by pyrite. The Bridgeport B reservoir is characterized by sandstone intervals with herringbone and reverse laminated bedding features and intervals of high angle tabular cross-bedded sandstone. The reservoir in the Bridgeport B sandstone was identified as tidal channels encased in mixed mud flats. The third and uppermost reservoir unit in the Bridgeport, unit D represents cyclic deposition with shale and sandstone couplets of dark gray shale and subparallel laminated sandstone indicating tidal deposition. The reservoir in the Bridgeport B sandstone was identified as tidal channels encased in mixed mud flats. Thin coal units are found through the Cypress and Bridgeport indicating low-lying swamps and mashes in the tidal delta. An area of seven sq. miles at Lawrence field has been identified by Plains Illinois for prospective ASP flooding.

ASP Flood

The goal of ASP flooding at Lawrence field was to duplicate the oil recovery performance of the old surfactant floods at a lower cost. Costs are lowered by optimizing the synergistic performance of the three chemicals used, and by injecting the chemicals at a low concentration. Chemicals used in the ASP flood are an alkali (NaOH or Na2CO3), a surfactant and a polymer. The alkali (1 to 2%) washes residual oil from the reservoir mainly by reducing interfacial tension between the oil and the water. The surfactant (0.1 to 0.4%) enhances the ability of the alkaline to lower interfacial tension. The polymer (800 to 1400 ppm) is added to improve sweep efficiency.

The ASP chemical slug is injected first at approximately 30% pore volume. The polymer slug (approximately 25% pore volume) is injected next to push the ASP solution and maintain mobility control. Water is then injected to continue pushing the ASP and polymer slugs to the economic limit. **Figure 5** shows the pattern of the ASP pilot at Lawrence field. Well spacing shows an injector pattern of 5 acres. Separate injection tests were performed on the Bridgeport and Cypress sands. The targeted ASP oil recovery for the project is 13.5% pore volume. The mini-

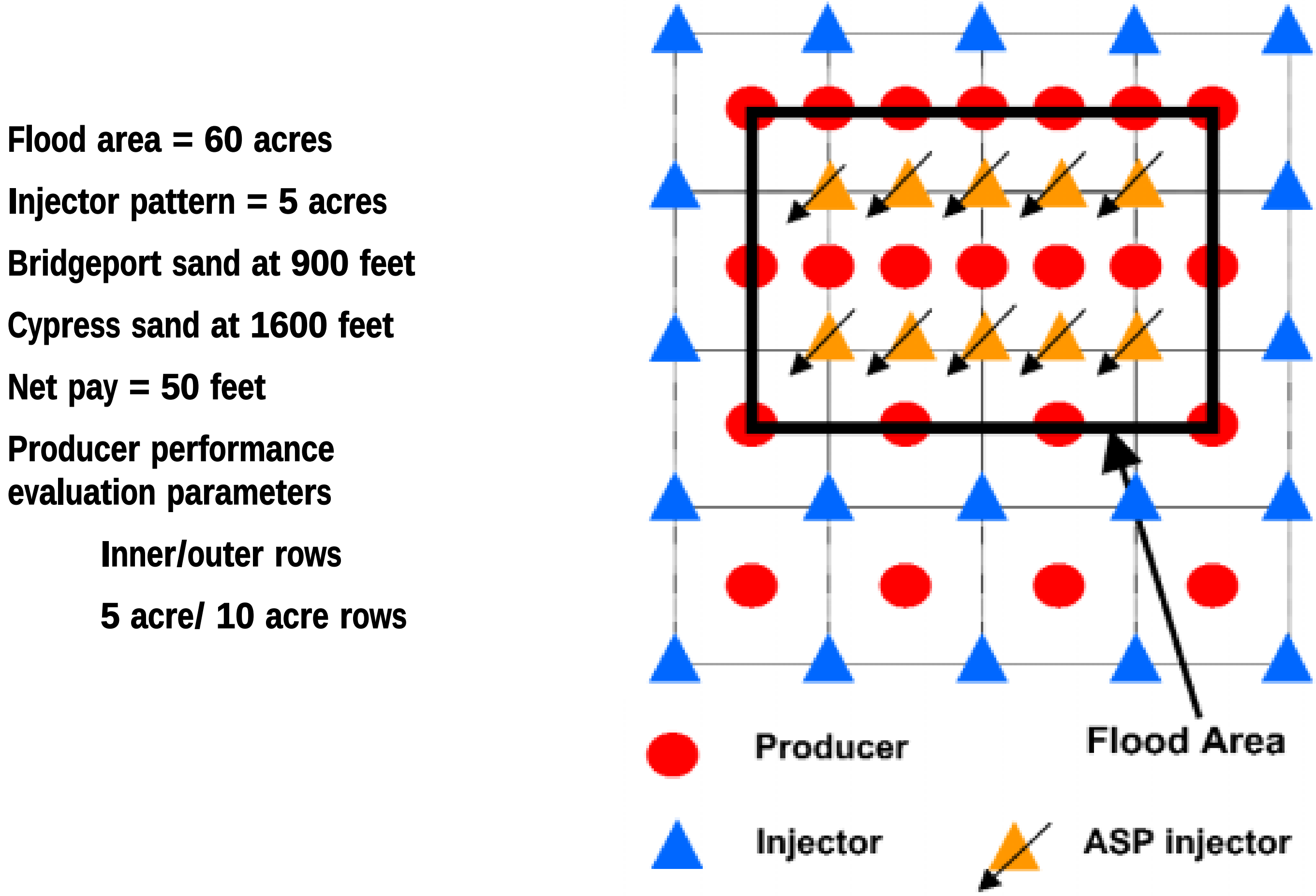

Figure 5. The Pilot ASP flood pattern indicating close spacing of ASP and water injectors and producing wells.

mum net pay sand thickness targeted for each well was 40 ft.

Summary

The ASP flood pilot at Lawrence field utilizes three flood patterns with simultaneous ASP injection in the Bridgeport and Cypress sandstones. At the beginning of the project production from both reservoirs averaged less than 3% oil cut. Analysis and modeling of the reservoir characterization data and initial results indicate that oil recovery can be increased significantly. **Figure 6** shows the decline curve predicted prior to the ASP flood, and curve and volume of oil projected to be recovered by the ASP flood. Based on the initial success of the ASP pilot Plains Illinois estimates that the full field project will be self-funding after 3 years. Reservoir life is anticipated to be extended for an additional 14 years. Future development plans by Plains Illinois include expanding the ASP floor to 320 acres in the seven-mile prospect indicated in **Figure 3**.

Acknowledgments

Plains Illinois, Inc., Surtek Inc., Landmark Graphics Software, U.S. Department of Energy. TCA

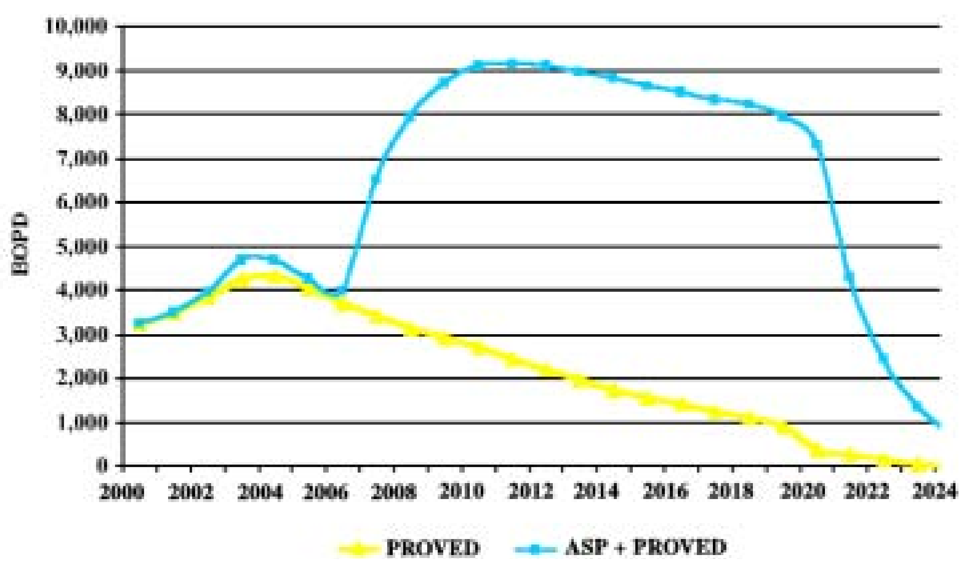

Figure 6. Decline curves at the Lawrence Field ASP pilot. Production had peaked and was in a steep decline following 96 years of primary and waterflood recovery. The projected ASP flood will increase ultimate recovery and extend reservoir life.

West Virginia PUMP Workshop

Under DOE's PUMP Phase I, West Virginia University Research Corporation in Morgantown, West Virginia was selected to demonstrate the best practices to overcome regional production obstacles. PUMP called for identification of specific regional obstacles to oil production, and the preferred management practices to overcome the problems. The West Virginia University Research Corporation organized a council of with members of the Petroleum Technology Transfer Council (PTTC), the Appalachian Oil and Natural Gas Research Consortium Advisory Board, and oil industry representatives. The method addressed to identify problems and solutions was a "Problem and Preferred Management Practices Workshop". The first workshop was held in Morgantown, WV in January 2002*.

There were several goals for the workshop: to introduce key players in the Appalachian Bain oil industry to DOE's new Preferred upstream Management Practices (PUMP) program; to explain the various elements of the two-year project in detail; to transfer technology through a series of short, invited talks; to identify technical problems and best management practices; and to recruit members for the Preferred Management Practices Council.

Participation of the state geological surveys of Kentucky, New York Ohio, Pennsylvania, and West Virginia assisted in preparing estimates of reserves, production and a list of the largest oil producers in each state and contact persons for each. Invitations were sent to key individuals explaining the PUMP program and soliciting speakers for the workshop. **Table 2** gives the reserves and cumulative production from each state based on 1998 data.

Table 2. Oil Reserves and Production

Kentucky	23MM	3.00 MM
New York	2.4 M	217 M
Ohio	40 MM	6.54 MM
Pennsylvania	15 MM	1.36 MM
West Virginia	17 MM	1.48 MM
TOTAL	95 MM	12.06 MM

Source: Data from EIA and State Geological Surveys, 1998.

Invited speakers for the technology transfer portion of the workshop were:

- Virginia Lazenby, chairman of the Bretangne Group, Lexington, KY (keynote speaker)
- Stanley Pickens, retired chairman & CEO of Dominion Appalachian Development, Inc., Jane Lew, WV (keynote speaker)
- Lance Cole, PTTC's Project Manager, Tulsa, OK
- Kevin Smith, chairman of the PTTC Appalachian Region Producer Advisory Group from Oxford Oil, Zanesville, OH.
- Tim Knobloch, James Engineering, Marietta, OH
- Steve Smith, Airlift Services, Anderson, IN
- Ali Rdissi, Carthage Software, Inc. McKees Rocks, PA
- Bernie Miller, Bretagne Group, Lexington, KY
- Carl Starr, CNR/NiSource, Charleston WV

Lance Cole gave a brief overview of the Petroleum Technology Transfer Council's efforts to promote information of emerging technologies and case studies form a number of projects nationwide. He concluded that "operators should not be afraid to look outside their out area; they can learn from other's successes – and failures–so they, in turn, should be willing to share their experiences".

Kevin Smith made two presentations; one on *Brine Disposal in Ohio*, which described successful, low-cost methods of disposal of produced brines. The second presentation *Assessing Uphole Reserves Behind Pipe* described a quick, inexpensive method to identify and evaluate reserves behind pipe.

Tim Knoblock addressed the necessity of maximizing production and profitability from stripper wells in *Production Monitoring Practices*. Technical problems often go undetected unless production rates are closely monitored for abnormal declines. Four methods of production monitoring include reliance on pumpers, tabular monitoring, percentage rule and computerized systems. Because monitoring production is not a part of a pumper's normal work, this method often fails. Tabular and percentage monitoring compares month to month responses, but do not have sufficient information for adequate monitoring. A computer based system allows real time data collection and manipulation. The program recommended, "Priority" succeeds because it compares actual production to forecasted production volumes, and highlight only those wells that require attention, allowing managers to prioritize production, and organize the correct field level response.

Steve Smith presented a talk and video on *An Innovative Air Lift System for Oil Wells* developed by airlift Services. The compressed air system is self-contained, with no moving parts above ground, and only plastic, stainless steel and brass components placed in the well. The system is capable of lifting up to 25 barrels of fluid peer day from depths up to 1,500 ft. The system eliminates corrosion problems and does not require a beam, motor or pulleys, and labor costs are also reduced.

Real-Time Monitoring System to Improve Production and Accuracy at the Wellsite presented by Ali Rdissi, suggested using a hand-held computer to record data, and eliminate common errors made in the field. Entering accurate gage measurements, and following them with error-free calculation, goes a long way to diagnosing production problems in the field while still at the well site. **Figure 7** shows the laser scanner and hand held computer used for wellsite monitoring.

Bernie Miller described a new *Membrane Technology to Produce On-Site Nitrogen for Enhanced Oil Recovery*. This high-pressure, portable nitrogen generator produces nitrogen for use in huff and puff EOR processes. Examples from eastern Kentucky showed an how nitrogen injection has increased oil production using this unit. **Figure 8** illustrates the portable nitrogen generation unit.

Figure 7. Psion Workabout MX Laser Scanner

Carl Starr discussed efforts to pump oil wells that have low gas-to-fluid ratios in *Pumping Wells in Appalachia: Problems and Remedies*.

In addition to the formal presentations the workshop offered three breakout sessions.

- Data Collection – Use, Needs, Automation and Management
- Reservoir Characterization, Heterogeneity and Compartmentalization
- Drilling Stimulation and Production

In the Data Collection breakout the participants agreed that as a standard format for all states, digital data is highly desirable. Other topics discussed were the location and condition of old records on plugged and abandoned wells, and cost effective ways to ways to assemble data for making decisions. Another issue discussed was the differences in state requirements on annual reports and maintaining records systems.

The reservoir characterization group discussed current practices in the Appalachian Basin. Participants decried the trend towards not taking any cores from new wells, despite the valuable information core analysis supplies. Geological modeling, data integration, and access to company and government reports on field data were addressed. The speakers noted that technologies such as cross-well tomography, magnetic surveys and surface geochemical surveys, and even seismic surveys are not widely used in the Appalachian Basin compared to

Figure 8. Nitrogen Membrane Unit. This membrane unit gives the ability to generate nitrogen gas on site. This technology allows nitrogen to be generated on site at a cost much less than other gases.

other parts of the country.

The breakout group on Drilling, Stimulation and Production surveyed participants on activities in Kentucky, New York, Ohio, Pennsylvania, Tennessee and West Virginia. The survey ranked the following drilling problems in order of importance;

- Drill rig safety
- Region-wide lack of drilling personnel
- Aging and poorly maintained equipment – unavailability of new equipment
- Increasingly complex permitting and regulatory process
- Drillers unprepared for high pressure /high volume flow in new wells

* Based on the Annual DOE report by Douglas G. Patchen, West Virginia University Research Corporation. TCA

Improved 9-Component Vertical Seismic Profiling

Visos Energy Corporation has successfully demonstrated 9-component Vertical Seismic Profiling technology (VSP) to identify drilling targets and recompletions in the Morrow sandstone. Visos Energy worked with the Bureau of Economic Geology at The University of Texas at Austin as their research unit partner*. The 9-C technology provides an improved seismic reflection interpretation of the Morrow surface for more accurate stratigraphic imaging. 9-C technology will reduce exploration and exploitation risks, making it attractive to majors and independents.

Visos and geophysicists from the Bureau of Economic Geology at The University of Texas at Austin evaluated Vertical Seismic Profiling to improve seismic interpretation of the Morrow Formation. The objective of the U.S. Department of Energy (DOE) cost-shared project was to evaluate P-wave and S-wave imaging options to identify potentially productive oil zones in the Morrow sandstone reservoirs.

Background

Oil production from the Morrow Sand Trend of Colorado, Kansas, Oklahoma and Texas is from fluvial channel reservoirs. Optimum drilling sites in the Morrow have been difficult to determine using conventional 3-D seismic survey methods that utilize only compressional (P) waves (waves traveling in the direction of the original seismic signal). The Morrow sand reservoirs do not always generate sufficient reflected P-wave energy for interpretation, thus a broad area affecting several hundred independent operators cannot be exploited in a cost-effective manner.

A preliminary study by the Colorado School of Mines found that those Morrow reservoirs that did not generate P-wave seismic reflections often produced robust shear wave (S-wave) reflections. Scientists at The University of Texas at Austin independently confirmed this S-wave phenomenon and developed techniques to correlate P and S- waver reflection data with Morrow stratigraphy. Using 9-component VSP technology, which generates both compressional and shear waves, data from three test wells in Colorado, Kansas and Texas were successfully acquired, processed, and analyzed.

Technical Development

Nine-component VSP data were acquired at the three Morrow test well locations using vertical arrays of 3-component geophones and three distinct vector (directional) seismic sources (vertical vibrator, inline horizontal vibrator, crossline horizontal vibrator). **Figure 9** shows the vibrators stationed at one of the Morrow wells where a 9-C VSP survey was recorded. To record 9-C VSP data, you have to use 3-C geophones downhole and three orthogonal vector-displacement sources on the Earth surface. The direct P-wave arrival from a large-offset vertical vibrator was used to orient the downhole receivers.

Three fundamental seismic wave modes were identified; compressional (P) mode, the horizontal shear (SH) mode, and the vertical shear (SV) mode. The seismic vector-wavefield motion associated with these three modes in simplest form can be described, respectively as in-and-out, up-and-down, and back-and forth. The diagram in **Figure 10** shows the three fundamental wave modes that are captured with 9-C VSP data. Each mode creates a different vector displacement of the Earth as it propagates. Each displacement vector (wave mode) provides different information

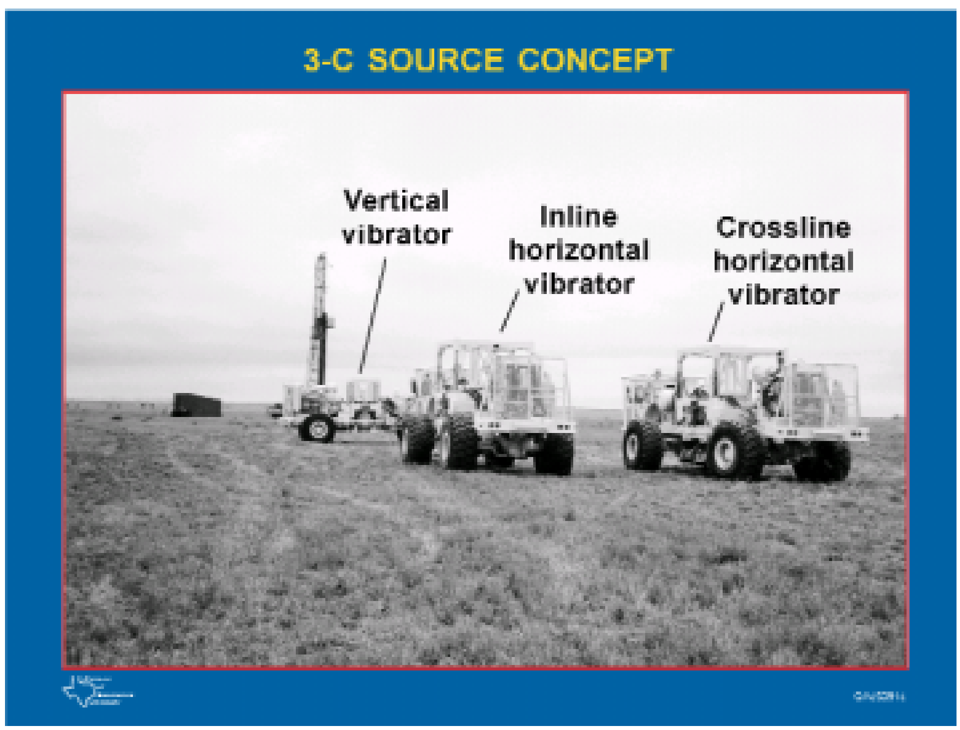

Figure 9. The photo shows the three vibrators at a Morrow well test site. The VSP well is in the background, behind the vibrators.

about rock and fluid properties and reacts to different stratigraphic surfaces along the propagation path. Identification and interpretation of these modes is related to stratigraphic depth and is key to the interpretation of surface-recorded seismic data. Sometimes one wave mode shows a stratigraphic surface better than do the other wave modes. Depth-based displays of the P, SH and SV images can be directly compared with well logs and depth-based engineering data.

S and P-wave reflections were analyzed across the Morrow sand at each well site. S reflections often arrived from different subsurface stratigraphic surfaces than P-waves. Together the P and S images were found to give improved and more detailed indication of Morrow reservoir architecture than the more conventional use of P-waves alone. In the Morrow the S reflections were often more robust that the P reflections. Vertical resolution of S-wave images was as good as the vertical resolution of P-wave images. Thus surface recorded S-wave data should provide a spatial resolution of Morrow targets that is equivalent to the resolution achieved with P-wave surface recorded data in other reservoirs.

9-C VSP data confirmed that S reflections often occur at different Morrow stratigraphic surfaces than do P reflections. This reflectivity behavior means that the combination of P and S reflection images will result in improved stratigraphic interpretations of Morrow prospects. Because operators rarely know what stratigraphic sequences exist at a Morrow prospect, results of this project indicate that all Morrow prospects should be evaluated with both P and S seismic multi-component data rather than with conventional 3-D seismic.

Benefits

The success of the partnership between Visos Energy and The University of Texas at Austin to demonstrate the use of shear wave data resulted in the startup of a new company, Vecta Technology, L.P., to commercialize this emerging technology. Vecta Technology suggests that the use of shear wave data is a breakthrough that can be applied in other reservoirs where P-wave data are inadequate. Research has continued through a 3-year $15 million project with Vecta, The University of Texas at Austin, and a consortium of industry partners. The technology is currently being demonstrated in the Permian Basin. Use of 9-C VSP and surface recorded seismic data could result in the discovery of billions of additional barrels of oil across the United States.

Statements from Dawson Geophysical of Midland, TX say that 9-C seismic technology is considered a major advance similar to the 3-D seismic breakthrough made 20 years ago for imaging structural traps. 9-component seismic technology is expected to allow producers to get images of more the porous sections of rock formations where oil and gas are found. The technology is also expected to allow operators to image compartmentalized areas of reservoirs where bypassed oil remains. The new technology is roughly double the cost of conventional 3-D seismic, however, it is expected to reduce drilling risk, result in more discoveries, and recover significant bypassed oil.

*Based on data supplied by Tom Coffman, Vecta Technology; and Dr. Robert Hardage, Bureau of Economic Geology, The University of Texas at Austin. TCA

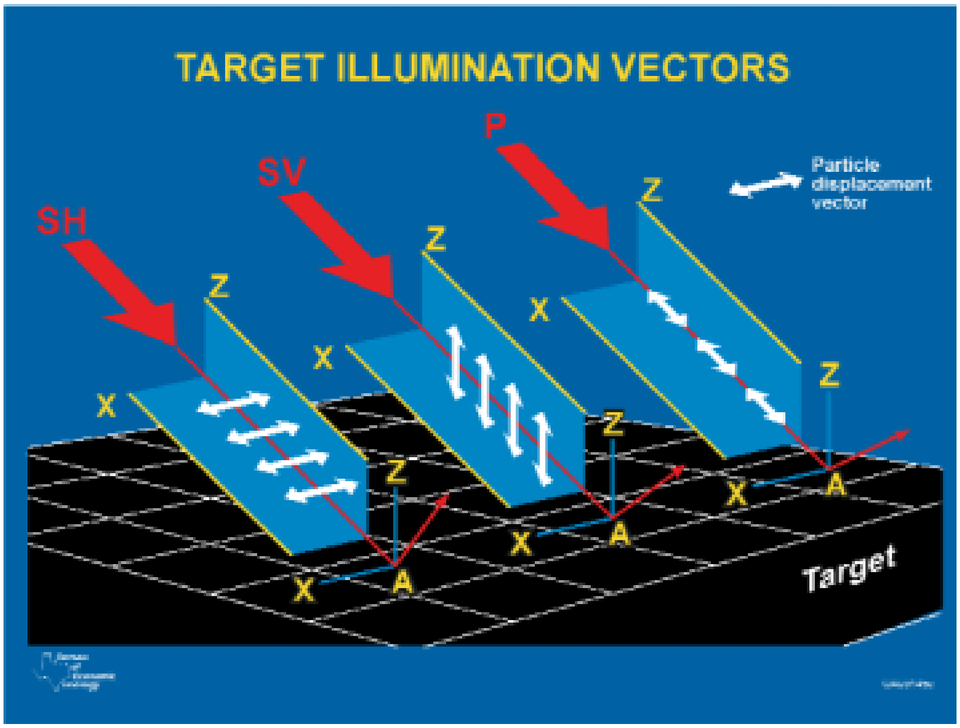

Figure 10. The directional movements of the wave modes used in 9-C VSP data is illustrated. The broad red arrow associated with each downgoing mode shows the direction of propagation. All three modes are propagating in the same direction to illuminate the subsurface target. The particle displacement associated with each mode is shown by the smaller double-headed arrow drawn along the propagation path.

Solicitations on NPTO Website

Program Soliciation DE-PS26-02NT15376, "Advanced Technology Development by Independents For High Risk Domains." The closing date for submission of proposals is September 6, 2002.

Applications will either address: 1) Existing Fields - established production areas of the Gulf of Mexico and Alaska and Rocky Mountain Frontier regions, or 2) Exploration - in the very complicated environments of the Gulf of Mexico and Alaska and Rocky Mountain Frontier regions.

Program Soliciation (PS) DE-PS26-02NT15377, "Technology Development with Independents."

Pre-application due 12 August 2002, DOE Pre-selection notification 27 August 2002. Complete Application due 26 September 2002.

Program Soliciation DE-PS26-02NT15375, "Public Resources Invested in Management and Extraction (PRIME)." The closing date for submission of applications is July 15, 2002.

This new initiative will focus on longer-term fundamental R&D in the three broad areas: 1) Oil and Gas Recovery Technology; 2) Advanced Drilling, Completion, Stimulation, and Operations (ADCS), 3) Advanced Diagnostic & Imaging Systems (ADIS) & Reservoir Characterization.

Comments on all three solicitations are encouraged and welcomed, and should be transmitted through the "Submit Question" feature of IIPS.

To download the solicitation and submit proposals, go to the DOE website **http://www.npto.doe.gov/business/procure.html** TCA

Shallow Shelf Carbonate DOE Class II Project Review

Photo credit: Santa Rita #1, 1923 Permian Basin, Courtesy of Charles Kerans, Bureau of Economic Geology, University of Texas, Austin.

October 18, 2002, Odessa, TX - Participants from all completed and active DOE Class II and Class II Revisit projects will be invited to participate in a review of the technologies, project development and results. The project review will offer the public the opportunity to benefit from the technologies applied in carbonate basins and formations across the U. S. including; the Permian Basin, Paradox Basin, Williston Basin, Michigan Basin, Mississippi Interior Salt Basin, and the Mid-Continent. The speakers will be asked to summarize their projects emphasizing benefits, lessons learned, and the spread of the technologies in the region.

DOE will release the new Class II CD, which will contain Final reports and interim reports from the original nine Class II projects. Copies of the CD will be distributed, and copies of annual reports from all Class II and Class II Revisit projects will be made available.

The project review will run from 8:30 a.m. to 5 p.m. with lunch at the CEED facility. Additional information will be available on the NPTO website as workshop plans are finalized. www.npto.doe.gov TCA

The **Class Act**
The Department of Energy's National Energy Technology Laboratory's National Petroleum Technology Office is proud to bring you information on field demonstrations that benefit domestic oil producers.

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Contributing to *The* Class Act
If you have a news item or project to feature in an upcoming issue, please contact the editor.

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Summer 2002

C A L E N D A R

Meetings and Announcements

September 29-October 2 Society of Petroleum Engineers (SPE) Annual Meeting, San Antonio, TX
www.spe.org

October 7-11 Society of Exploration Geophysicists (SEG) Annual Meeting, Salt Lake City, UT
www.seg.org

October 15-17 Permian Basin International Oil Show, Odessa, TX
www.pbioilshow.org

October 18 DOE Class II Review, CEED, Odessa, TX
www.npto.doe.gov

October 30-November 1 American Association of Petroleum Geologists (AAPG) Gulf Coast Section Meeting, Austin, TX
www.aapg.org

May 11-14, 2003 AAPG/SEPM Annual Convention, Salt Lake City, UT **www.aapg.org**
DOE Poster session #P-34
"Development of DOE-Funded Projects"

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