The Class Act

DOE's Reservoir Class Program Newsletter

Volume3/1

Winter 1997

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GET THE RIGHT $TUFF

You need not spend mountains of money to achieve effective reservoir management. Reservoir characterization is a complex process by which you gain knowledge of the reservoir from a wide variety of engineering and geological data sources. Powerful tools and techniques for reservoir characterization continue to emerge, but efficient and cost-effective reservoir characterization is still more often viewed as an art than as a science.

Building an effective reservoir management plan requires knowing:

- **Business environment**
- **Technologies to describe, analyze, and exploit the reservoir**
- **Reservoir system including its rocks, fluids, wellbores, and surface facilities**

Class projects in this workshop show you practical approaches to obtain the "right" reservoir information for making critical reservoir decisions in a cost-effective manner. Come see for yourself, you may walk away with a million dollar idea!

CLASS WORKSHOP ON RESERVOIR CHARACTERIZATION

by Mike Fowler, BDM-Oklahoma

Explore the relationship between reservoir characterization and reservoir management at a workshop associated with the 4th International Reservoir Characterization Technical Conference to be held March 2–4, 1997, in Houston, Texas. Case histories from three reservoir classes at the Sunday afternoon workshop (March 2nd) will highlight how appropriately scaled approaches to reservoir characterization lead to successful reservoir management.

RESERVOIR CLASSIFICATIONS

DOE's cost-shared Class Program projects are demonstrating the practical and profitable application of existing and newly developing technologies in depositionally similar reservoirs. Techniques proven successful in projects within a depositional reservoir class have a high probability of applying to other reservoirs within that class. Just as important, the practical approaches to reservoir decision-making being demonstrated apply to all reservoirs.

About 30 projects representing combined industry and government investments in excess of $250 million are now in place. Integrated reservoir characterization plays a pivotal role in each project, but the projects selected for this workshop emphasize reservoir characterization and the innovative use of technology to manage mature clastic and carbonate reservoirs effectively and efficiently.

Specific presentations and poster sessions will demonstrate how good reservoir management contributes to cost-effective reservoir characterization in the:

- Highly heterogeneous fluvial-dominated deltaic reservoirs of Class 1
- Low-permeability shallow-shelf carbonate reservoirs of Class 2
- Siliciclastic deepwater turbidite reservoirs of Class 3

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Technologies Covered

Avoiding common mistakes of the past, maximizing the use of available data, and design and implementing customized reservoir management plans will be emphasized. Highlights of the technologies to be presented include:

- Use of wireline logs to build depositional facies models for optimally locating infill wells
- A working technique to determine reservoir permeability profiles from log data
- Integrated use of multiple data types (e.g., core, log, injection/production well test, 3-D seismic)
- Optimizing waterflood and steamflood
- Targeted completions
- Use of deviated wells to recover uncontacted resources

Workshop Presentations

Class Program Workshop Presentation and Poster Sessions will include the following:

- **Application of Borehole Imaging for Reconstruction of Fluvial Architecture,** Dennis Kerr, University of Tulsa, Class 1, Bartlesville Sandstone, OK; Glenn Pool Field.
- **Defining Flow Units Based on Pore and Rock Typing,** Jerry Nevans, Fina USA, Class 2, Clearfork, West TX; N. Robertson Unit.
- **Combining Flow Theory and Multiple Log Readings to Improve Permeability Calculations,** Greg Hinterlong & Archie Taylor, Oxy USA, Class 2.
- **An Integrated Study to Identify Additional Waterflood Reserves,** Robert Trentham, Laguna Petroleum, Class 2, Grayburg/San Andres, West TX; Foster and South Cowden Fields.
- **Integrated Reservoir Characterization to Enhance Steam-flood Recovery,** Steve Schamel, Univ. of Utah, Class 3, Monarch Sandstone, CA; Midway-Sunset Field.
- **Characterization of the Distal Margin of a Slope-Basin Reservoir,** James Boles & Douglas Imperato, ARCO Western Energy, Class 3, Monterey Shale, CA; Yowlumne Field.

Don't Forget to Register

Participants may register for only the Class Workshop, or for the entire Conference (Class Workshop included). For registration information, contact Susan Hayden:

Phone: (918) 337-4460
Fax: (918) 337-4339
e-mail: shayden@bpo.gov

Conference/Workshop Fees

Conference Fee—$300 U.S. (includes proceedings, luncheons, workshops, and receptions)
Student Conference Fee—$125 U.S.
Workshop Only Fee—$100 U.S.

Class Projects—A Key Player in 4th International Reservoir Characterization Technical Conference

Class Program projects also are prominent among the regular conference papers and posters at the 4th International Reservoir Characterization Technical Conference. Here's a quick summary of some Class Project activities in the nonworkshops areas.

Class Technical Conference Sessions

Monday, March 3rd, 11a.m.

New Developments in High Resolution Borehole Seismology and Their Application to Reservoir Development and Management: Bjorn Paulsson, Chevron Petroleum Technology Co., Class 3

Monday, March 3rd, 2:30 p.m.

Predicting Interwell Heterogeneity in Fluvial-Deltaic Reservoirs: Outcrop Observation and Applications of Progressive Facies Variation Through a Depositional Cycle: Paul Knox & Mark Barton, BEG, Univ. of Texas, Austin, Class 1.

Tuesday, March 4th, 4:30 p.m.

Advanced Reservoir Characterization for Improved Oil Recovery in a New Mexico Delaware Basin Project: D. F. Martin, R. P. Kendall, E. M. Whitney, Dave Martin & Assoc.; R. A. Hardage, BEG; B. A Stubbs, Pecos Petroleum (Strata Production), Class 3.

Class Posters (Evenings)

Petrofacies Analysis–The Petrophysical Tool for Coherent Reservoir Characterization & Management: W. L. Watney, et al., Univ. of Kansas, Class 2.

Enhanced Oil Recovery in the Midway-Sunset Field, San Joaquin Basin, CA; DOE Class 3 Oil Technology Demonstration Project: Univ. of Utah; S. Schamel, et al.

The *Class* Act is a quarterly newsletter devoted to providing information about DOE's Reservoir Class Program. The newsletter is produced by BDM-Oklahoma, which manages the National Oil Program for the Department of Energy (DOE) in Bartlesville, Oklahoma.

For more information on Class Program projects, contactHerb Tiedemann at DOE's National Petroleum Technology Office (NPTO):

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Using Excel-Based Well Log Analysis Software Easy as Falling off a Log

by W. Lynn Watney, Kansas Geological Survey, University of Kansas

PfEFFER stands out as a spreadsheet-based log analysis software that is affordable, easy to use, and practical for real-time, interactive log analysis. The minimum log data required by the software–which runs on a PC or Macintosh as an add-in to Excel–is a porosity and resistivity log. Data from old logs can be digitized or simply typed into the spreadsheet. Oil producers familiar with Microsoft Excel will have a short learning curve using PfEFFER.

PfEFFER's spreadsheet database and graphic features allow both rapid analysis and comparing of multiple interpretations or best case/worst case scenarios.

PfEFFER can solve many log analysis problems by offering multiple, user-driven solutions. Multiple wells and zones are easily managed in a familiar workbook and spreadsheet organization. Project files can be generated that assemble reservoir parameters, grids them, and displays them as 2-D maps or 3-D surfaces.

Name

PfEFFER stands for *Petrofacies Evaluation of Formations for Engineering Reservoirs*.

Developers

John H. Doveton, Willard Guy, and W. Lynn Watney with programming support from Saibal Bhattacharya, Geoff Bohling, Dana Adkins-Heljeson, Greg Pouch, and Saif Ullah at the Kansas Geological Survey, University of Kansas.

Field Testing

In two DOE/BDM-Oklahoma projects: Schaben Field, Class II Field Demonstration Project, and the Digital Petroleum Atlas. Results can be examined and downloaded on the Internet via the home page at the Kansas Geological Survey at this URL: http://www.kgs.ukans.edu/DPA/Schaben/Reservoir/schabenRese1.html.

Goals of Analyses Using PfEFFER:

- Resolve reservoir parameters that control performance
- Characterize subtle reservoir properties important in understanding and modeling
- Define hydrocarbon pore volume and flow units
- Expedite recognition of by-passed, subtle, and complex oil and gas reservoirs
- Systematically differentiate commingled reservoirs to aid in reservoir management and improved recovery
- Assist in integrating large amounts of geological and engineering information to improve reservoir modeling and to define appropriate recovery, technologies
- Offer simple, efficient, and practical tools to help geoscientists, engineers, petroleum operators

Ordering Information

Available from the Kansas Geological Survey, 1930 Constant Avenue - Campus West, University of Kansas, Lawrence, Kansas 66047; phone.: 913/864-3965, fax: 913/864-5317. Or, order PfEFFER over the Internet at ww:URL:http:/ /www.kgs. ukans.edu/

Cost

Version 1.0 or Version 1.1 costs $295.00. Version 1.0 owners will receive a free upgrade.

Version 1.0 (Released in January 1996)

- Runs as an add-in to Excel version 5.0c or later on IBM-compatible personal computers (486 or better) or a Power Macintosh.
- Is written in Visual Basic using about 8,000 lines of code.

Operating Modules in Version 1.0:

- Reading log ASCII standard (LAS) digital files
- Constructing a "Super Pickett" crossplot annotated with lines of water saturation, bulk volume water, and permeability
- Depth plots of parameters
- Lithology solution
- Capillary pressure analysis
- Mapping
- Development was cosponsored by 12 companies and Kansas Technology Enterprise Corporation. The companies provided data and financial support and tested the prototypes during a one-year development.

Also check this URL for details: http://www.kgs.ukans.edu/PRS/software/pfeffer1.html.

New Features in Version 1.1 Due by February 1997

- Basic log analysis functions
- New toolbars including v-shale, porosity calculation, and moveable oil.
- Development was cosponsored by BDM-Oklahoma and four industry cosponsors.

Future Enhancements

PfEFFER Pro for advanced reservoir characterization and modeling is being funded by DOE and is scheduled for mid-June 1997 release. The enhancements for PfEFFER Pro include:

- New toolbar and modules facilitate reservoir characterization including cluster analysis and shingled block lattice as tools to distinguish reservoir types and flow units
- Automates the construction of cross sections and adapts geographic information system (GIS) mapping technology to standardize map displays
- Provides links to DOE's black oil simulator, BOAST III
- Defines and characterizes pay zones and flow units
- Constructs movable oil plots
- Conducts shaley log analysis
- Applies Hough transform for simultaneous solution of Archie equation constants and formation water resistivity
- Analyzes and displays "secondary porosity"
- Offers petrophysical forward modeling, generates synthetic petrophysical logs, and provides alternative model scenarios
- Links output of PfEFFER to DOE's BOAST III reservoir simulator.
- Standardizes map displays from PfEFFER using geographic information systems approaches

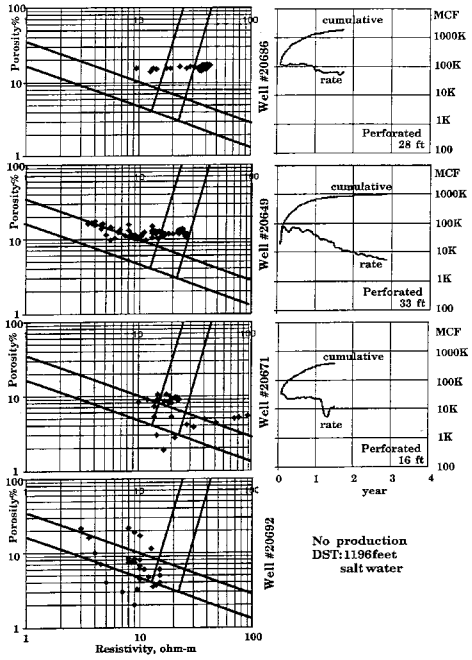

Figure 1 Pickett crossplots and corresponding production histories for the Lower Morrow sandstone in Arroyo Field, Stanton County, Kansas.

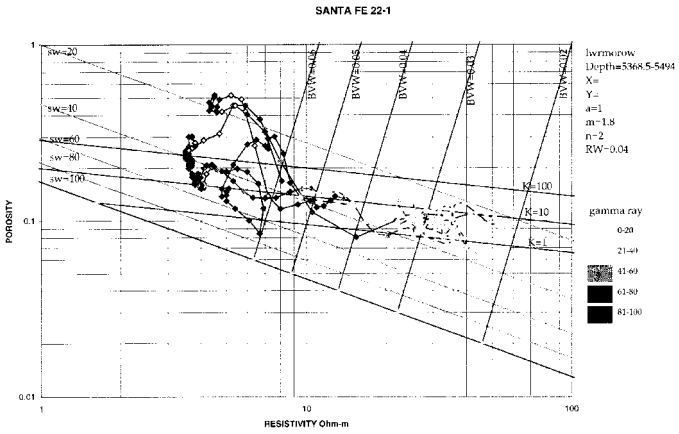

Figure 2 Pickett crossplot of Lower Morrow quartz sandstone reservoir annotated with gamma ray

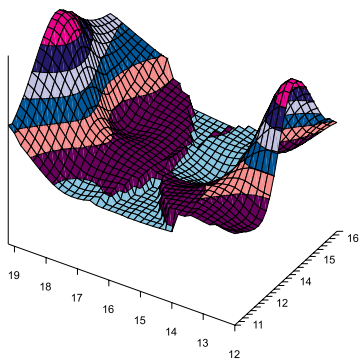

Figure 3 3-D of minimum bulk volume water map

COSIM Compresses Simulation Time

by Asnul Bahar and Mohan Kelkar,
University of Tulsa

What Can COSIM Do?

COSIM, a *free* 3-D geostatistical program that works on a PC running Windows 95/NT, generates at the same time both the grid block value of consistent petrophysical properties (porosity and permeability) and the underlying geological description (facies, rock type, etc.). This reduces storage requirements and makes computations more efficient. COSIM produces a detailed reservoir description which can later be used as the input for a numerical flow simulator.

In the oil industry, generating a reservoir description usually involves two stages: (1) constructing a geological description, then (2) describing petrophysical properties through a filtering process. In contrast, COSIM visits each grid block just once. Using the same search neighborhood, COSIM first estimates the geological facies, followed by porosity and permeability values. The method accounts for correlations among these variables, as well as the spatial relationships.

How Do I Get a Free Copy?

Call Mohan Kelkar, Department of Petroleum Engineering, at (918) 631-3036, or download a copy from the Internet at: **http://darcy.utulsa.edu/-ab/cosim.htmi**

What Data Are Needed?

1. Well log and core information are needed. The well log is mainly used for facies and porosity simulation; whereas, core information is used for permeability simulation.
2. A geologist's interpretation– because a well log does not contain the facies/rock type information directly.
3. The spatial analysis (vario-gram) of the data is required for each facies, and for porosity. Efforts will be made to include this analysis in a future release.

What's the Result?

COSIM displays the result directly on the screen. Version 1.0 includes a 2-D cross-section imager. The user can view any cross section desired using selected attributes (color, scale, and size).

Has COSIM Been Tested?

COSIM has been tested on both sandstone (Glen Pool Field) and carbonate (North Robertson Unit, West Texas) reservoirs. For Glenn Pool field data, a geologist used a *discrete genetic interval* (DGI) as the geological unit. In each DGI, several facies (such as channel fill, crevasse splay, floodplain mudstone) are defined. In all, six DGIs were defined, DGI A through F. A comparison (Fig. 1) between the simulation results and the geologist's interpretation indicated that the generated petrophysical properties were consistent with the underlying geological description. Also, the simulation repli-cates the vertical sequence of each DGI seen in the field very well.

In the case of the North Robertson Unit data, the geologist used the geological unit of rock type. This task was to simulate the rock type distribution and the corresponding porosity/permeability values.

What's Planned?

In the future, COSIM will offer

- Variogram analysis
- Statistical analysis of input data and simulation output
- Seismic information

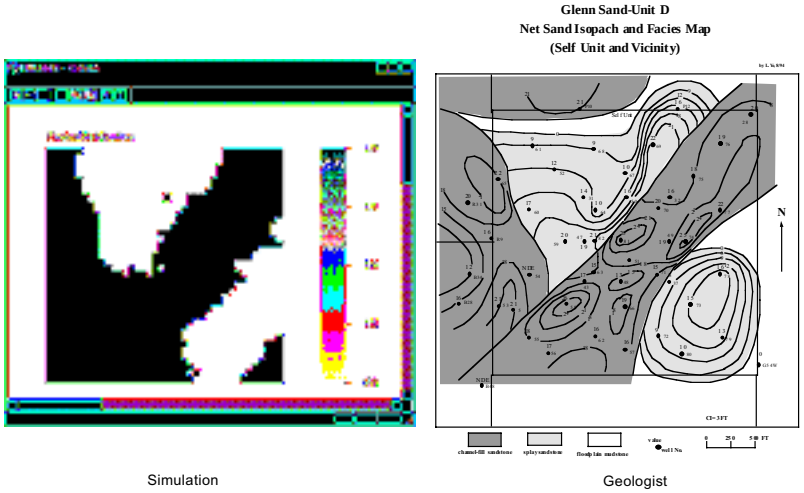

Figure 4 Comparison between a simulation result and a geologist's interpretation of DGI D

A Software Guide to Integrated Reservoir Characterization and Prioritization

by Paul Knox, W. Gerald White, Mark H. Holtz, and Jeffrey G. Paine,
Bureau of Economic Geology, University of Texas at Austin

As the DOE's Reservoir Class Program has shown, tremendous volumes of recoverable oil remain in mature domestic reservoirs. Finding and exploiting such opportunities is a growing but increasingly competitive business for the domestic oil industry. Successful companies will be those who apply advanced technologies such as 3-D seismic imaging, high-frequency sequence stratigraphy, and reservoir modeling to constrain risk and reduce finding costs. Profitability will be maximized by seeking out and prioritizing opportunities, same as with exploration prospects.

Software for Reservoir Prioritization for PCs

Companies and asset teams with limited experience in integrated multidisciplinary reservoir characterization will need to acquire or hone skills and develop a methodology for prioritizing prospective reservoirs. To meet this need, the Bureau of Economic Geology of the University of Texas, with support from DOE, has created a PC-based software program that provides an illustrated interactive guide to reservoir characterization with an emphasis on Class 1 (fluvial-dominated deltaic) reservoirs.

This program, **Reservoir Characterization Advisor–Fluvial Deltaic (RCA–FD)**, allows an operator to enter basic information about a series of reservoirs and use a built-in algorithm to *estimate the relative potential that those reservoirs contain remaining resources.* The intent is to provide a quick but quantitative basis for a decision that is typically made subjectively.

Factors Considered

Factors used in the estimate include:

1. Relative reservoir size–the larger the reservoir initially, for a given percentage recovery efficiency, the greater the volume of unrecovered oil
2. Past completion density
3. Reservoir heterogeneity–both structural and stratigraphic (which can be estimated by examining facies and position within the depositional cycle)
4. Hydrocarbon mobility–greater mobility results in more thoroughly drained reservoirs, which can be estimated by analyzing mean permeability, oil gravity, and percentage of the reservoir originally occupied by gas
5. Reservoir depth–which is an economic risk factor (the deeper a target of a given volume, the higher the drilling costs and the lower the financial return)
6. Any existing gas-vs.-oil preference of the operator resulting from commodity prices, infrastructure, or general company strategy

The Results Display

Data from each analysis (i.e., from a specific group of reservoirs) is saved as a separate dataset and can be retrieved and modified at any time. A "results" screen displays a ranked list of the reservoirs and a scrollable, editable inset window containing a summary of the values entered for each reservoir.

Characterization Methodology

Confidence in locating the remaining oil in a mature reservoir requires integration of geological, geophysical, and engineering data to accurately identify reservoir architecture as well as volumes of original and produced hydrocarbons. RCA–FD provides the necessary fundamentals and applications of advanced technologies in each science, as well as presenting a methodology for integrating these diverse disciplines (for a methodology overview, see the Summer 1996 *Class Act*).

The application of advanced technologies is described with examples from south Texas Frio Formation fluvial-deltaic reservoirs investigated during the four years of the Bureau's Class 1 study.

Geologic principles presented within the program include discussions of (1) deltaic processes, (2) deltaic facies, (3) sequence stratigraphy and causes of depositional cyclicity, and (4) predictable changes in facies and delta morphology through a depositional cycle that influence reservoir

production behavior (Figure 1).

A section on 3-D seismic acquisition and interpretation covers:

1. Designing a survey to limit costs while optimizing data quality in the reservoir interval
2. Determining seismic resolution and imaging thinly bedded reservoirs
3. Time-to-depth conversion using checkshots, synthetic seismograms, and vertical seismic profiles (VSPs)
4. Structural and stratigraphic interpretation, including horizon-slicing methods. This portion of the methodology section concludes with a discussion of application and integration of geologic and geophysical data to identification of reservoir architecture

Another portion of the methodology section of the program provides information on application of pressure-volume-temperature fluid behavior, production time-series analysis, and direct evaluation of flow barriers to identification of intrareservoir fluid flow.

An approach is then presented to integrate reservoir architecture, historic fluid flow trends, and volumetric analysis to identify the volume and location of remaining hydrocarbons. The methodology section is supplemented by an extensive bibliography of critical references in each discipline.

The program will be demonstrated at this year's AAPG meeting in Dallas during the Wednesday poster session, "Results of Joint DOE/Industry Programs."

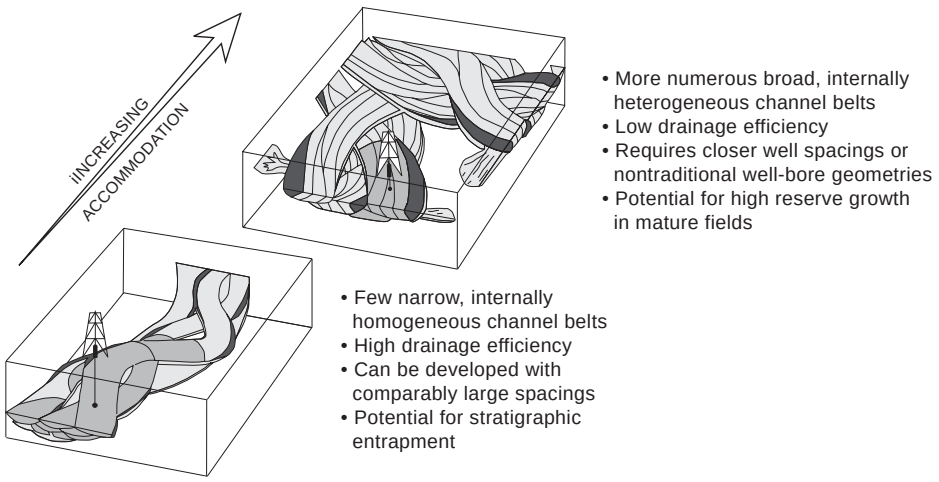

Figure 5 An illustration from RCA–FD demonstrating the effect on the drainage behavior of fluvial-deltaic reservoirs deposited under high- and low-accommodation conditions. The model was developed during DOE-supported research on Frio reservoirs in south Texas.

How to Get a Copy

RCA–FD will be available this spring for purchase at a price covering only the cost of reproduction. RCA–FD operates on any PC-compatible computer with a 386 or better CPU running Windows 3.1 or Windows 95. An SVGA monitor is required to display the graphics and animations.

C A L E N D A R

JANUARY

Jan. 30, Midland, TX; ***Spraberry Symposium*** *at CEED,* hosted by Parker and Parsley Petroleum (Class 3), Paul McDonald.

FEBRUARY

Feb.-April 1997, (offshore) ***Field Trips to Carpenteria Field*** *(Class 3),* Pacific Operators Offshore, Santa Barbara, CA, & PTTC.

Feb. 10-12, Bakersfield, CA; ***SPE International Thermal Operations and Heavy Oil Symposium,*** Presentation by City of Long Beach on the Wilmington Field (Class 3), Scott Hara.

Feb. 18, Midland, TX; ***Permian Basin Section SEPM,*** Luncheon Talk, "Impact of Subaerial Exposure of the San Andres Reservoir, Foster Field, Ector Co., Texas": Laguna Petroleum, Robert Trentham.

Feb. 20, Midland, TX; ***Permian Basin Well Log Society,*** "Petropyhsics of the Ramsey Sandstone, Ford Geraldine Unit, Reeves and Culberson Counties, TX": G. B. Asquith, (Class 3) BEG, Univ. of Texas, Austin.

Feb. 27, Prairie View, TX; ***Workshop*** sponsored by Texaco E & P and Texas A & M, presentation by Sami Bou-Mikael (Class 1).

MARCH

Mar 2-4, Wyndham Greenspoint Hotel, Houston, TX; ***DOE / BDM-Oklahoma / AAPG Fourth International Reservoir Characterization Technical Conference;*** (See article on page 2 for details.)

Mar 19-20, Wichita, KS; ***Tertiary Oil Recovery Project's 12th Improved Oil Recovery Conference,***

"Implementation & Monitoring of the Stewart Field waterflood"; Lanny Schoeling, Univ. of Kansas (Class 1).

"Savonburg Project Progress Report"; Lanny Schoeling, Univ. of Kansas (Class 1).

"Problems in the Use of Air Flotation for Cleaning Produced Water"; Lanny Schoeling, Univ. of Kansas (Class 1).

"Enhanced Carbonate Reservoir Model for an Old Reservoir Utilizing New Tech-

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niques:The Schaben Field (Mississippian) Ness Co., KS"; Univ. of Kansas (Class 2) Tim Carr.

Mar 21, Austin, TX; **Society of Independent Professional Earth Scientists,** "Petrophysics of Submarine-Fan Sandstones of the Ramsey Sandstone Reservoir, Ford Geraldine Unit, Delaware Basin,TX"; G. B. Asquith, (Class 3) BEG, UT, Austin.

Date to be announced in March, Midland,TX; **1-Day Workshop**; "Reservoir Characterization of Permian Deep-Water Sandstones, Bell Canyon Formation, Geraldine Ford Area, West TX (Delaware Basin)"; Shirley Dutton, Class 3, BEG, UT, Austin.

APRIL

April 7-9, Dallas,TX; ***AAPG Annual Meeting,***

"Basin Floor Fan & Channel-Levee Complexes, Permian Bell Canyon Formation"; poster by M. D. Barton, Class 3, BEG, Univ. of Texas, Austin.

"Geophysical Characterization of Permian Deep-Water Sandstones, Bell Canyon Formation & Cherry Canyon Formation, Geraldine Ford Area, West TX (Delaware Basin)"; poster by A. G. Cole, Class 3, BEG, Univ. of Texas, Austin.

"Reservoir Characterization of Permian Deep-Water Ramsey Sandstones, Bell Canyon Formation, Ford Geraldine Unit, West TX (Delaware Basin)"; poster by S. P. Dutton, Class 3, BEG, Univ. of Texas, Austin.

"Combination of Magnetic Resonance & Classic Petrophysical Techniques to Determine Pore Geometry & Characterization of a Complex Heterogeneous Carbonate Reservoir"; Univ. of Kansas (Class 2) W. J. Guy, et al.

"Advanced Reservoir Characterization for Improved Recovery in New Mexico's Delaware Basin"; Strata Production, Class 3, Bruce Uszynski.

"Enhanced Oil Recovery in the Midway-Sunset Field, San Joaquin Basin, California: A DOE Class 3 Oil Technology Demonstration Project"; Univ. of Utah; S. Schamel, et al.

"Reservoir Modeling of the Anasazi Carbonate Mound, Paradox Basin Utah"; Utah Geol. Survey, D. M. Lorenz, et al.

"Improving Primary Oil Recovery from a (DOE Class 1) Fluvial-Dominated Deltaic Lacustrine Reservoir Uinta Basin, Utah"; Utah Geol. Survey, Craig Morgan. Booth & Poster by Michigan Technical Univ. (Class 2), Wayne Pennington.

April, Lubbock, TX; ***Southwestern Petroleum Short Course,*** Progress report, "An Integrated portion of the Foster (San Andreas) Field Ector Co., TX"; Laguna Petroleum; Robert Trentham, Richard Weingrant, & William Robinson.

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