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VISUAL DISPLAY OF RESERVOIR PARAMETERS AFFECTING
ENHANCED OIL RECOVERY

ANNUAL Report

By
Michigan Technological University

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Performed Under Contract No. DE-FC22-94BC14892

Michigan Technological University
Houghton, MI

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**Bartlesville Project Office
U. S. DEPARTMENT OF ENERGY
Bartlesville, Oklahoma**

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Visual Display Of Reservoir Parameters Affecting
Enhanced Oil Recovery

Annual Report

By
James R. Wood

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Work Performed Under Contract No. DE-FC22-94BC14892

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ANNUAL REPORT

VISUAL DISPLAY OF RESERVOIR PARAMETERS AFFECTING ENHANCED OIL RECOVERY

OBJECTIVE

This project consists of two parts. In Part 1, well logs, other well data, drilling, and production data for the Pioneer Field in the southern San Joaquin Valley of California were obtained, assembled, and input to a commercial relational database manager. These data were used in PC-based geologic mapping, evaluation, and visualization software programs to produce 2-D and 3-D representations of the reservoir. Petrographic and petrophysical measurements made on samples from Pioneer Field, including core, cuttings and liquids, were used to calibrate the log suite. In Part 2, these data sets were used to develop algorithms to correlate log response to geologic and engineering measurements.

This project provides a detailed example, based on a field trial, of how to evaluate a field for EOR operations utilizing data typically available in older fields which have undergone primary development. The approach utilizes readily available, affordable PC-based computer software and analytical services. This study illustrates the steps involved in: 1) setting up a relational database to store geologic, well-log, engineering, and production data, 2) integration of data typically available for oil and gas fields with predictive models for reservoir alteration, and 3) linking these data and models with modern computer software to provide 2-D and 3-D visualizations of the reservoir and its attributes. The techniques were demonstrated through a field trial in Pioneer Field, that produces from the Monterey Formation, a reservoir which is a candidate for thermal EOR.

SUMMARY OF TECHNICAL PROGRESS BY TASK

TASK 1. PROJECT ADMINISTRATION AND MANAGEMENT

1.1 THE SPATIAL DATABASE MANAGER

The Multimedia Database Management System (MDMS) has been developed in the commercial software package Toolbook. Design and implementation, which was carried out by C. Asiala, is now essentially complete. Regional location maps of southern San Joaquin Valley oil fields, structure contour maps of the Pioneer area, core photos, core data, thin-section and SEM photomicrographs of core materials, structural cross sections through Pioneer Anticline, an atlas of photomicrographs illustrating typical diagenetic features observed in San Joaquin Valley petroleum reservoirs, elemental and spectral data collected on Fourier Transform Infrared Spectroscopy (FTIR) standards, and all quarterly and annual reports submitted to DOE for this project were scanned into the MDMS. All data and information are accessible through drop-down menus and hotlinks in a Table of Contents (Fig. 1). A tutorial is presented up front to guide users through the MDMS and instruct them on the various ways in which data can be viewed and retrieved. Version 1.0 of the MDMS was written to CD ROM and distributed to participants in a Technology Transfer Workshop in Bakersfield, CA, in September, 1996. Version 1.1, which contains additional information and has been reorganized for easier use, is nearing completion.

All measured and computed log curves (computed curves represent parameters such as porosity, water saturation, and clay content, which were calculated from the measured log traces using specially developed algorithms) for the 45+ project wells on Pioneer Anticline are now in the MDMS in LAS (log ASCII) format, and can be exported to any commercial log evaluation program for manipulation and analysis. All log curves were written to the CD ROM in digital format.

C. Asiala developed a search engine in Microsoft Access which can be used to retrieve logs from the CD ROM. Any desired log curve can be located using queries and then exported from the CD ROM to temporary Access tables created on the computer's hard drive. Once in the Access tables, log curves can be manipulated or transferred to log evaluation packages such as GeoGraphix's QLA2 or Crocker's Petrolog program for analysis and plotting. A tutorial describing how to use the search engine was written and is now available as on-line help. This CD ROM will contain not only all project results, but also *all project data including all well logs in digital format*, and will be the primary deliverable of the project.

1.1.1 DATABASE INITIALIZATION

Database initialization is complete.

1.1.2 DATABASE MANAGEMENT

All project data are managed and archived in the Multimedia Database Management System that was developed in Toolbook (see Subtask 1.1). Log evaluation was carried out at differing levels of sophistication in the programs Pfeffer, QLA2, Crocker Petrolog, and Symbiolog. Maps and cross sections were prepared using GeoGraphix Exploration System (GES) software. Three-dimensional visualizations were prepared in the software package MatLab.

Microsoft Access is our relational database management platform. All of the log data are stored in Access in LAS format. All other data are stored Toolbook, in multimedia form, accessible via pulldown menus and a Table of Contents with hot links. Instructions for retrieving logs from the Access database are included in the Toolbook multimedia archive. Users can search the database by query and retrieve the logs from the main database table by well or by log type. Logs are then placed in smaller temporary Access tables from which they can be exported to applications programs. We have a log database which is independent of all of our well-log evaluation programs (Crocker Petrolog, GeoGraphix QLA2, and TerraSciences TerraStation), but is capable of exporting data to any one of them.

A commercial database containing over 77,000 geochemical analyses of brines recovered from wells throughout the United States was organized and input to Microsoft Access. Analyses of samples from California wells are now easily retrievable for use in our DOE project.

The GeoGraphix Exploration System software package was acquired in fall 1995 and installed on a PC in the Subsurface Laboratory at Michigan Technological University (MTU). Since that time we have acquired an academic license and three additional seats on GeoGraphix. Graduate students S. Chittick and W. Everham attended a training course at GeoGraphix' headquarters office in December and Professor J. Huntoon and graduate student W. Houston attended in February. We now have four Dongal keys to GeoGraphix and can run the program at multiple sites, which will greatly enhance progress. Chittick spent a week at Digital Petrophysics, Inc. (DPI) in Bakersfield in January loading their log and formation-top data into GeoGraphix. He has since produced excellent maps of the Miocene unconformity (including all fault traces) and has contoured the maps to grid. Graduate student W. Houston has constructed numerous cross sections through Pioneer Anticline (Fig. 2) and has constructed structure contour maps on the tops of several formations (Fig. 3).

1.2 ORGANIZATION AND MANAGEMENT

The management tasks continued to go smoothly this quarter.

1.2.1 PROJECT COORDINATION

The following trips and meetings were held this year:

On November 13-14, 1995, Wood, Pennington, Gruener, Allan and Nigrini traveled to DPI in Bakersfield to review progress on the log evaluation part of the project and to plan and make arrangements for a Technology Transfer Workshop to be held in September, 1996.

On November 14, Wood Allan and Nigrini met with R. Robinson, the Director of the California Well Sample Repository at California State University, Bakersfield, to make arrangements for holding the workshop there.

In early December, Nigrini visited Davis-Namson Consulting Geologists in Glendale, CA to discuss the Elk Hills deep well study. Davis-Namson recently completed a structural study of Pioneer Anticline and provided us with a copy of their geologic map and cross section of the Pioneer area.

On January 10-14, Wood traveled to the University of South Florida (USF) in Tampa to initiate the 3-D visualization work with M. Luo.

On January 15-16, Wood, Gruener, Chittick, Allan and Nigrini visited DPI to review project progress and to set up the GeoGraphix Exploration System software on a computer in their office. On January 16, Wood and Allan visited the California Well Sample Repository to continue discussions with R. Robinson about our September 1996 workshop. Chittick remained at DPI until January 21 to work with D. Olson of DPI on the importation and manipulation of log data to GeoGraphix.

On January 17, Olson and Berry of DPI presented a talk on their log evaluation program Symbiolog to the Society of Professional Well Log Analysts (SPWLA) at their luncheon in Bakersfield and used the Pioneer DOE project as their principal case study to illustrate application of the new program.

On February 10-11, J. Allan and W. Pennington traveled to Bakersfield to review progress on log analysis with D. Olson at DPI.

On February 10-15, M. Luo traveled to MTU to work on MatLab visualizations with MTU faculty and graduate students.

On March 4-5, Wood and Allan visited DPI in Bakersfield to review project progress and visited R. Robinson to formalize plans for our September 1996 Technology Transfer Workshop and contract for Robinson's services to set up the workshop at the California Well Sample Repository.

In April, M. Luo and J. Allan traveled to Michigan Technological University (MTU) to work on the Pioneer project with MTU faculty and staff.

In May, Allan traveled to DPI in Bakersfield to review progress on the Symbiolog analysis of Pioneer wells with F. Berry.

In May, MTU ran a booth in the Exhibit Hall at the AAPG National Meeting in San Diego, CA. The booth featured the Pioneer Field DOE Project. F. Berry and D. Olson presented computer demonstrations of their Symbiolog program in the booth. A. Nigrini presented a poster display of his Elk Hills study at the California Well Sample Repository core exhibit, which was located elsewhere on the Exhibit Hall floor.

In June, W. Pennington presented a talk entitled "3-D Visualization Techniques for Very Small Field Operators" at the Society of Exploration Geophysicists' (SEG) Production and Development Forum.

During the summer of 1996, graduate student W. Houston worked at Santa Fe Energy Resources in Bakersfield, CA, as a geological trainee. In his summer project, he utilized GeoGraphix to evaluate reservoir continuity and heterogeneity in a 130-well lease in a San Joaquin Valley oil field. The skills he acquired while carrying out this project put him in a position to make important contributions to our DOE projects when he returned to MTU in the fall.

In August and September, M. Luo and J. Allan traveled to MTU to work on the Pioneer project with MTU faculty and staff.

On September 24, 1996, project staff held a Technology Transfer Workshop in Bakersfield, CA. Presentations were made by J. Wood, W. Pennington, J. Allan, M. Gruener, M. Luo, W. Houston, and J. Suchoski of MTU; F. Berry and D. Olson of DPI; and R. Robinson of the California Well Sample Repository. Twenty two people attended.

1.2.2 BUDGET MANAGEMENT AND QUARTERLY REPORTS

M. Gruener and A. Hein are responsible for daily management of the budget and expenditures. A. Hein prepares the quarterly financial reports and distributes all reports to DOE. J. Allan is responsible for quarterly and annual technical reports.

TASK 2. DATA COLLECTION

2.1 WELL LOGS AND WELL DATA

The tops of the Etchegoin Formation, the Monterey Formation, and the Reef Ridge Member were correlated between project wells. Top picks were made on all logs and corrected for well deviation. The top of the Monterey was mapped in detail. Fault cuts were picked from log cross sections and fault traces were plotted on the top-Monterey contour map. All of the Monterey

data were loaded into GeoGraphix and a structure contour map was produced with all faults displayed (Fig. 3). Fault intersections were mapped on the tops of the Etchegoin and Reef Ridge as well.

D. Crane of DPI later completed several cross sections through the Pioneer Anticline. Faults were correlated and mapped in a much more sophisticated fashion than previously, and fault-plane maps of all of faults which cut the Miocene section in the Pioneer area were prepared. These included both normal and thrust faults. Crane picked the tops of the following formations in all project wells: the Etchegoin Formation, the Monterey Formation, the Reef Ridge Sandstone, and the Reef Ridge Shale. Formation tops are being contoured using GeoGraphix. Fault planes, with true azimuths and dips, and fault intersections with each formation were plotted in 3-D surface visualizations in MatLab.

J. Alex completed the digitization, editing, and coloration of the surface geological maps of the southern San Joaquin Valley which were originally prepared by Dibblee of the California Division of Mines and Geology. Alex is continuing this work by preparing several additional maps and cross sections, including a geologic map and cross section of the Pioneer area which we recently acquired from Davis-Namson Associates.

DPI completed the analysis of all Pioneer project wells using their newly developed log-evaluation program Symbiolog. An innovative procedure was developed for using modern log suites, calibrated to core data, to evaluate wells for which only old electric logs (e-logs) are available. This procedure was used to calculate parameters such as porosity, water saturation, and clay content, which are not directly measured by these old logs. The evaluation procedure is based on an iterative process in which petrophysical data collected on core material are calibrated to logs in wells with full modern log suites. Porosity, water saturation, clay content, etc., are calculated from the full log suite using algorithms and then cross-checked against values measured in core. The same parameters are then calculated using only the basic electric-log suite. Algorithms are adjusted until parameters derived from the core, the full-log suite, and the e-log-only suite all show reasonable agreement within the logged interval. When an acceptable level of agreement is achieved, the algorithms can be used to calculate porosity, saturation, and lithology in old e-log-only wells.

Successful results were achieved. Porosity, saturation, and lithology were calculated for all wells in the Pioneer study area, including wells with full modern log suites, wells with intermediate-aged log suites, and wells drilled in the 1930's and 1940's for which only e-log suites are available. The computed curves for all 45+ project wells were delivered to MTU.

2.1.1 LOG DATABASE MANAGEMENT

All measured and computed log curves are stored in the MDMS in LAS format and are retrievable using Microsoft Access as a search engine. Log evaluation is being carried out using the programs Pfeffer, QLA2, Crocker Petrolog, and Symbiolog. Pfeffer is a simple, inexpensive (\$290.) log-evaluation software package developed by University of Kansas researchers; QLA2 is an intermediate-level log-evaluation package suitable for general use by exploration and

development geologists that is provided as a module with the GeoGraphix Exploration System; and Crocker Petrolog and Symbiolog are sophisticated log-evaluation programs suitable for use by formation-evaluation specialists.

W. Pennington is responsible for log analyses using Pfeffer and QLA2, while DPI is responsible for log evaluations using Crocker Petrolog and Symbiolog. A comparison of the different programs was presented at our Technology Transfer Workshop in Bakersfield, CA in September, 1996, in order to provide attendees information that will enable them to perform a simple cost/benefit analysis and choose the software that is best fits their needs.

2.1.2 LOG DIGITIZATION

Digitization of all of the well logs necessary for construction of maps and 3-D visualizations of the Miocene and Pliocene reservoirs on Pioneer Anticline is complete.

2.2 CORE AND SAMPLE ACQUISITION

2.2.1A CORE AND CUTTINGS

Our conventional and sidewall core library of samples is complete. It consists of conventional cores and core analysis data from the UNOCAL McKittrick Front Nos. 415 and 418 wells in Cymric Field and the Tenneco 62x-30 well in Pioneer Field. Sidewall core and cuttings samples and core analysis data from the Gary Drilling, KLC 44, Well No. 375x in Pioneer Field are also in our sample library.

2.2.1B ARCO/UNOCAL CORE

J. Allan arranged for the core and core data from the UNOCAL McKittrick Front Nos. 415 and 418 wells in Cymric Field to be released by UNOCAL to the California Well Sample Repository at California State University, Bakersfield for our Technology Transfer Workshop. The cores and core data from the two McKittrick Front wells are so outstanding that acquiring core data from additional wells to calibrate our logs has proved unnecessary. They were shipped to the Repository and are now in storage there. We hope to be able to arrange the eventual donation of the core and samples to the Repository, where they will reside in perpetuity and can be used as a resource by both industrial and research geologists.

2.2.2 FLUIDS

A data set containing over 77,000 geochemical analyses of brines recovered from wells throughout the United States was acquired from a commercial database vendor. C. Asiala designed a Microsoft Access database and archived the brine data in it.

TASK 3. DATA ANALYSIS AND MEASUREMENT

3.1 PETROPHYSICS

3.1.1 POROSITY, PERMEABILITY, FORMATION FACTOR (KPF) MEASUREMENTS

Extensive petrophysical data sets were acquired from UNOCAL for the cores from the UNOCAL McKittrick Front No. 415 and 418 wells in Cymric Field. A petrophysical data set for the Tenneco 62x-30 well in Pioneer Field was acquired independently. Petrophysical data from the cores were used to calibrate the logs in these wells. The calibrations were used to analyze existing logs and produce computed logs in uncored wells which penetrate the same stratigraphic intervals on the Pioneer Anticline (see Subtask 2.1).

3.1.2 FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR) SPECTRA

Current efforts concentrate on obtaining better standards for Opal A and CT. Since the FTIR work represents the M.S. thesis research project of graduate student N. Popko, it will continue after the completion of this DOE contract.

3.2 PETROLOGY

3.2.1 XRD

Reports on completed Xray work were prepared by R. Kramer. Xray work is essentially complete. Any additional work that is performed will be done in conjunction with Popko's FTIR work.

3.2.2 SCANNING ELECTRON MICROSCOPY (SEM)/IMAGE ANALYSIS

Epoxy mounts of selected Pioneer samples were subjected to image analysis and Energy Dispersive Spectral (EDS) analysis on the SEM. All electron photomicrographs and Energy Dispersive Elemental (EDS) analyses were archived in the Toolbook Multimedia Database Management System this quarter.

3.2.3 PETROLOGY

Optical petrographic analyses are complete for 44 thin sections of the Monterey reservoir in our cored wells. Results include petrographic descriptions, 35mm slides, and 35mm prints of thin sections which are characteristic of each lithologic type. All photomicrographs and thin section descriptions were scanned into the MDMS.

An atlas of thin section petrology of representative reservoir samples from the southern San Joaquin Basin was acquired for the project. The atlas was compiled by M. Hayes at Chevron

Research under the direction of J. Wood in 1988. The atlas, which consists of several hundred described and interpreted photomicrographs from many fields, emphasizes diagenetic alteration. The photomicrographs and their captions were scanned into the MDMS.

3.3 LOG CALIBRATION

Log calibration is complete for all project wells.

3.3.1 DATA PREPARATION

Data preparation is complete for the 45+ wells in the original Pioneer Anticline study area plus five additional "regional" wells which were added to the data set to extend our picture of the Anticline up-plunge to the west. Data from these wells have been entered into GeoGraphix. The additional 26 wells in our formation-tops spreadsheet are old wells which do not have usable borehole geophysical logs. The picks in these old wells were made from drillers' logs.

D. Crane of DPI picked the tops of the Etchegoin Formation, the Monterey Formation, the Reef Ridge Sand, and the Reef Ridge Shale, in all project wells, and constructed fault-plane maps for all faults in the vicinity of Pioneer Field. The data were used by M. Luo to construct 3-dimensional visualizations of the Pioneer Anticline in MatLab. The results of his 3-D visualizations, with "slice and dice" capability, are quite impressive, and were presented at our Technology Transfer Workshop.

3.3.2 MODEL SELECTION

Final analysis of all well logs from all Pioneer project wells was completed using the program Symbiolog, developed by log analysts and programmers at DPI. Symbiolog uses a newly developed technique called multi-facies zone summation analysis. Conventional log analysis packages apply one set of cutoffs (porosity, residual water saturation, etc.) to a reservoir. Multi-facies zone summation analysis allows the user to define different facies within a reservoir and to assign a different cutoff value to each facies. Expected production within a heterogeneous reservoir can be estimated much more precisely this way than with the conventional approach.

The new parameters and algorithms were recently tested on the two McKittrick Front wells with modern logs suites by running one set of calculated logs utilizing all of the modern log and core data and a second set of calculated logs on the same intervals using only the spontaneous potential and one resistivity log. The output curves for the two runs were very similar, suggesting that output from the electric-log-only well runs will closely approximate the calculated curves which would be obtained if full modern log suites were available for all of the wells (Fig. 4).

Customized parameter tables were developed from core data and modern log suites for use in special algorithms that compute lithology, % clay, % shale, matrix type, porosity, and S_w from old electric-log data and plot the results in log form. These calculations were performed on all 45+ Pioneer project wells and computed curves were generated.

TASK 4. MODELING

4.1 GEOCHEMICAL MODELING

The geochemical modeling program CHILLER was used by J. Suchoski to model fluid-rock interaction. This has very practical significance because of active steamflooding of the Monterey and Etchegoin Formations elsewhere in the southern San Joaquin Valley.

4.1.1 GEOCHEMICAL MASS TRANSFER

Geochemical mass transfer work using CHILLER was also performed by J. Suchoski.

4.1.2 THERMODYNAMIC DATABASE

Two databases were used. The thermodynamic database SOLTHERM contains thermodynamic information on fluid species, gases, and minerals. Over 400 species are contained in the database. The data are valid over a temperature range of 0°C to 300°C. The database containing information on oxygen isotopes, OXYBASE, is complete.

4.2 BASIN MODELING

Basin modeling work on fluid flow out of the deep San Joaquin Basin continued. M. Luo developed a number of new applications for constructing 3-D surface and volume visualizations and pseudo-seismic cross sections using the program MatLab. These new applications were demonstrated at the Technology Transfer Workshop using data from Pioneer Anticline.

4.2.1 GEOHISTORY

A. Nigrini's one-dimensional basin modeling effort using the program BasinMod, which focused on analysis of the Elk Hills 934-29R well in the Naval Petroleum Reserve, the deepest well (24,442 feet) in the San Joaquin Valley, is complete. Results were presented in a poster display at the AAPG National Meeting in San Diego, CA, in May and in a talk and poster display at the Technology Transfer Workshop in Bakersfield, CA, in September, 1996.

The Elk Hills 934-29R well has excellent equilibrated downhole temperature profiles based on continuous temperature logging and a good vitrinite reflectance (Ro) profile that provide for calibration of the paleo-heat flow. A generalized paleo-heat flow model for the southern San Joaquin Basin is provided by model studies of lithospheric plate interactions which predicts the thermal consequences of the complex plate interactions affecting the southern San Joaquin Valley. The results of the 1-D modeling study of Elk Hills 934-29R demonstrate that the downhole temperature profile observed in the well is *not* in equilibrium with observed Ro data (Fig. 5).

It appears that the elevated temperature profile may be due to episodic release of geothermal fluids. If correct, our interpretation suggests that all reservoirs shallower than approximately

17,000 feet are prospective. This is much deeper than any of the reservoirs presently being produced in the San Joaquin Valley, which are generally shallower than 10,000 feet.

J. Allan completed a fluid inclusion study of vein carbonate samples taken from core recovered from between 12,000 and 24,000 ft in the EH 934-29R well. All of the samples contain petroleum fluid inclusions that range from light oil in the shallowest samples, through condensate in the intermediate samples, to wet gas in the deepest sample, providing evidence that hydrocarbon migration has occurred throughout this deep section.

A paper describing the burial and temperature history of the EH 934-29R well is currently in preparation.

4.2.2 2-D AND 3-D FIELD VISUALIZATIONS AND BASIN MODELS

MatLab 3-D Visualizations: 3-D visualizations of the Pioneer Anticline continue to be developed in MatLab. This commercially available statistics and visualization package is both flexible and powerful and can easily perform both 3-D surface and 3-D volume visualizations. M. Luo loaded the formation-top and fault-trace data assembled by D. Crane of DPI into MatLab and constructed excellent 3-D surface and volume visualizations, which can be rotated to any orientation and sliced at any angle for viewing (Fig. 6). He added the capability to map accurate fault intersections on formation-top contour maps and project fault planes in 3 dimensions at any dip angle desired (Fig. 7). Results were presented at the Technology Transfer Workshop.

B. Wei is continuing to use MatLab to produce "pseudo-seismic" sections from SP and gamma ray-logs. Using Wei's program individual pseudo-seismic logs (log traces whose amplitudes have been color-coded to resemble seismic amplitude traces) can easily be selected from a map-view window and then displayed as well-log or pseudo-seismic cross sections (Fig. 8).

ER Mapper - J. Suchoski is developing our ability to use ER Mapper, Version 5.0, to input and output several types of graphics files to GeoGraphix. ER Mapper is a module that provides the GES with Geographic Information System (GIS) capabilities. We intend to import aerial and satellite photos into GeoGraphix, where we can overlay surface maps and surface data (roads, surface facilities, etc.) on the photographic images.

TASK 5. TECHNOLOGY TRANSFER

5.1 REPORTS

A Workshop Notebook that summarizes and illustrates all project activities, and a CD ROM, which contains the MDMS with all project data, maps, cross sections, interpretations, and reports, was distributed to Technology Transfer Workshop participants in September. A. Nigrini is currently preparing a paper on the BasinMod study of the deepest well in the San Joaquin Valley for publication.

5.2 MEETINGS AND WORKSHOPS

Technology Transfer Workshop

A Technology Transfer Workshop was held in the Walter Stern Library Building and at the California Well Sample Repository at California State University, Bakersfield on September 24, 1996. R. Robinson, the Director of the Repository, was instrumental in planning and arranging the event. Twenty two participants from major oil companies, independents, government agencies, and the oil and gas consulting community attended.

The Workshop included a core display and barbecue at the Repository. Cores from the McKittrick Front calibration wells (including portions of the 700-ft research core from the McKittrick Front 418 well) were on display, along with core from selected intervals in the Elk Hills 934-29R well that was used in our Geohistory modeling study. Poster displays accompanied the cores. All participants received a workshop notebook which summarized project results and Version 1.0 of the MDMS CD ROM.

American Association of Petroleum Geologists (AAPG) 1996 Annual Meeting

MTU once again ran a booth featuring the Pioneer Field DOE Project in the Exhibit Hall at the AAPG National Meeting in San Diego, CA, in May, 1996. Along with our normal poster display, the booth featured a computer-graphics display, projected onto a large screen, that presented an overview of project activities and results. F. Berry and D. Olson were also present in the booth and presented computer demonstrations of their Symbiolog program. The California Well Sample Repository hosted a special core exhibit at the meeting and A. Nigrini presented a poster display of his Elk Hills study at their core exhibit.

Society of Exploration Geophysicists' Production and Development Forum

In June, W. Pennington presented a talk entitled "3-D Visualization Techniques for Very Small Field Operators" at the Society of Exploration Geophysicists' (SEG) Production and Development Forum in Vail, CO.

Community Energy Night in Bakersfield

On April 23, A. Nigrini and R. Robinson presented the results of the Elk Hills study (see Subtask 4.2.1) at the Third Annual Community Energy night in Bakersfield, CA. This exposition, which is sponsored by organizations representing all facets of the petroleum industry, attracted an audience composed of community leaders, energy industry management, and California Division of Oil and Gas officials. The presentation was well-received, and particular interest was focused on Nigrini's evidence that depth to economic basement is greater than previously believed in the Elk Hills area.

FIGURE CAPTIONS

Figure 1. Table of Contents of Multimedia Database Management System. MDMS has been written to CD ROM and is the main project deliverable.

Figure 2. A structural cross section through Pioneer Anticline, prepared in GeoGraphix.

Figure 3. Structure contour map on top Miocene, Pioneer Anticline, prepared in GeoGraphix.

Figure 4: The results of the full-suite and e-log only analysis are compared for well 72-30. Track 1 shows the lithology analysis from the full log suite, Track 2 shows the same analysis using e-log only. Track 3 compared the effective porosity computed from the full suite (PHIEDW) and from the e-log only model (PHESDW). In Track 4, the clay volume curves from the two models are compared (VCLWDW from the full suite, VCWSDW from the e-log only model).

Figure 5. Plot of equilibrated (shut-in) downhole temperature and vitrinite reflectance vs depth for Elk Hills 934-29R well. Note that downhole temperature profile is not in equilibrium with Ro profile and that Ro values indicate that temperatures in the recent past must have been significantly lower than they are today.

Figure 6. 3-D volume visualization prepared in MatLab illustrating "slice and dice" capability.

Figure 7. Structure contour map on the top Miocene, Pioneer Field area, displayed as a 3-D surface visualization in MatLab. In this version, fault intersections with the top Miocene surface are currently displayed in their proper declinations as vertical planes, but can now be displayed at their true inclinations as well. Visualization was prepared in MatLab.

Figure 8. "Pseudo-seismic" display constructed from gamma-ray logs. Individual "pseudo-seismic" logs can be selected from wells shown in map view by drawing a section line on the screen. The color-coded logs are then displayed in cross section, as shown here.

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STRUCTURAL CROSS SECTION
PIONEER ANTICLINE LIMB
PIONEER FIELD - KERN COUNTY, CA
DATA AND LOGS PROVIDED BY DPI, BAKERSFIELD, CA

Drawn By: W. HOUSTON	Project: PIONEER 100K	Scale: 1 : 24,000
Geology By: W. HOUSTON	Date: SEPT. 1996	Prospect: GLOBAL
Drawn For: D.O.E. WORKSHOP	Drawing No: DOE2.GPF	

Figure 2

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STRUCTURE CONTOUR MAP

TOP MIOCENE UNCONFORMITY

(FAULT TRACES SHOWN IN PURPLE)

PIONEER FIELD - KERN COUNTY, CA

DATA PROVIDED BY DPI, BAKERSFIELD, CA

Drawn By: W. HOUSTON

Scale: 1 : 36,000

Geology By: S. CHITTICK

Project: PIONEER 100K

Prospect: GLOBAL

Drawn For: D.O.E WORKSHOP

Date: SEPT. 1996

Drawing No.: DOE1.GPF

Scale 1:38000.

Figure 3

Figure 4

Standard Model Depth Plot

Elk Hills 934-29R

Figure 5

Figure 6

29-Aug-96

3-D Visualization of the Top Miocene, Pioneer Field

Figure 7

Figure 8 "Pseudo-seismic" display constructed from gamma-ray logs. Individual "pseudo-seismic" logs can be selected from wells shown in map view by drawing a section line on the screen. The color-coded logs are then displayed in cross section, as shown here.