QUARTERLY REPORT
MICHIGAN TECHNOLOGICAL UNIVERSITY

October, 1995

Visual Display of Reservoir Parameters Affecting Enhanced Oil Recovery

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EXECUTIVE SUMMARY

Several people joined the project this quarter. C. Asiala was hired as a part-time database programmer. M. Sivek was hired as an undergraduate assistant to help in the programming. J. Alex joined the program as a part-time computer draftsman.

The GeoGraphix Exploration System software package was acquired last quarter, installed on a PC in the Subsurface Laboratory at MTU, and has been in use all summer. The USGS Digital Land Grid and the National Geophysical Data Center's Gravity Data CD ROM were acquired and installed on GeoGraphix. Development of the Multimedia Database Manager is continuing. B. Watkins is constructing an input interface to make it possible for anyone in the project (not just experienced programmers) to easily input any type of data or graphics to the Database Manager.

During this quarter, C. Asiala began developing Microsoft Access databases to archive analytical data and digitized log traces. Once in Access, this data can be transferred easily to a variety of applications software packages. Now that we have three different programs that store and manipulate digitized log traces (Crocker Petrolog, GeoGraphix QLA2, and TerraSciences TerraStation), there is an increased need to archive log data in one central location.

Graduate student S. Chittick worked all summer loading data into the GeoGraphix Exploration System and getting the software operational. QLA2, GeoGraphix's well-log package was also purchased. Although its analytical capabilities are less sophisticated than Crocker Petrolog, it appears that it may be used to produce excellent graphic log displays and cross sections. Digitized logs were loaded into QLA2 this summer and a few trial log cross sections were constructed.

At the 1995 DOE Review Meeting for Fossil Energy Contractors in Oklahoma, T. Carr (U. Kansas) presented a "pseudoseismic" model that is based on the precept that well logs can be substituted for seismic traces in visualization software and then analyzed as if they were regular seismic data. We purchased the numerical computation and visualization software package MATLAB and input several gamma-ray logs for a trial run. A "pseudoseismic" cross section was generated and the results were encouraging.

A new effort was initiated during the quarter. J. Alex digitized the surface geological maps of the southern San Joaquin Valley prepared by Dibblee of the California Division of Mines and Geology and loaded them into the computer drafting program Canvas, where he is editing, integrating, and combining them. When complete, the integrated map will be printed in large format on our new HP650C color plotter. Not only will this map be useful to the project, it will likely prove popular with the Bakersfield geological community.

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. The database is currently being organized in Microsoft Access. As soon as a California base map has been

gridded and input to GeoGraphix, the well locations for all California wells which contain brine analyses will be plotted on a basemap.

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 will be scanned into the Multimedia Database Manager, where they can be readily accessed on hard disk and eventually on CD ROM.

One-dimensional basin modeling activities were initiated this quarter with an analysis of the deepest well (24,442 feet) in the San Joaquin Valley (Elk Hills 934-29R in the Naval Petroleum Reserve) using the BasinMod program. The results of the 1-D modeling study of Elk Hills 934-29R demonstrate that the downhole temperature profiles observed in the well are not in equilibrium with the observed vitrinite reflectance (R_o) data. A present-day downhole temperature profile was calculated to be consistent with the observed R_o values using the assumption that R_o values were minimally influenced by the observed non-equilibrium temperature profile and still reflect the true regional temperature history. The predicted downhole temperature at 23,800 feet is 188°C, compared to an observed value of 218°C. The data suggest that non-equilibrium elevated temperature profiles may be caused by very recent release and upwelling of geothermal fluids during seismic activity related to growth of the Elk Hills structure. The very young age of the Elk Hills structure (<1,000,000 yrs.) provides tight time constraints on the process.

Work has begun on a Manual for a Project Workshop. The Manual will be used as the text for a course which will first be presented in Bakersfield, CA, probably in the fall of 1996. Previously, we had discussed initiating our technology transfer effort with a smaller workshop on database design and construction. We have now decided to discuss databases as a subsection of a larger workshop that covers the entire project. J. Wood issued a memo in September, 1995, which provided an outline for the workshop and course notes, created teams and appointed team leaders for each task, set goals for the content of each section, and established deadlines.

During this quarter, the current contents of the Multimedia Database Manager were written to CD ROM. The CD's are now available for use in presentations.

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DISCUSSION OF TECHNICAL PROGRESS BY TASK

TASK 1. PROJECT ADMINISTRATION AND MANAGEMENT

1.1 THE SPATIAL DATABASE MANAGER

Work on the Spatial Database Manager proceeded in several areas. C. Asiala is developing Microsoft Access databases to archive analytical data and digitized log traces. The GeoGraphix Exploration System software package was acquired last quarter, installed on a PC in the Subsurface Laboratory at MTU, and has been in use all summer. The USGS Digital Land Grid and the National Geophysical Data Center's Gravity Data CD ROM were acquired and installed on GeoGraphix. Development of the Multimedia Database Manager is continuing. B. Watkins is constructing an input interface to make it possible for anyone in the project (not just experienced programmers) to easily input any type of data or graphics to the Database Manager.

1.1.1 DATABASE INITIALIZATION

We have selected Microsoft Access as our database management platform. A Multimedia Database Manager shell/interface, written in Microsoft Visual Basic, continues to be developed to archive all project data. At present, it is fully operational and efforts are being directed toward making it more user friendly. Currently, project data reside in a number of programs, including GeoGraphix, Crocker Petrolog, Access databases, and the Multimedia Database Manager. During this quarter, C. Asiala began developing Microsoft Access databases to archive analytical data and digitized log traces. Once in Access, this data can be transferred easily to a variety of applications software packages. Now that we have three different programs that store and manipulate digitized log traces (Crocker Petrolog, GeoGraphix QLA2, and TerraSciences TerraStation), there is an increased need to archive log data in one central location.

1.1.2 DATABASE MANAGEMENT

The GeoGraphix Exploration System software package was acquired last quarter and installed on a PC in the Subsurface Laboratory at MTU. Graduate student S. Chittick worked all summer loading data into the program and getting the system operational. QLA2, GeoGraphix's well-log package was also purchased. Although its analytical capabilities are less sophisticated than Crocker Petrolog, it appears that it may be used to produce excellent graphic log displays and cross sections. Digitized logs were loaded into QLA2 this summer and a few trial log cross sections were constructed.

The USGS Digital Land Grid was also acquired. This data set contains surface data, such as the locations of roads, rivers, towns, etc., for the entire United States. The National Geophysical Data Center's Gravity Data CD ROM was also acquired and loaded into GeoGraphix. Both data sets for the state of Michigan were loaded into GeoGraphix as part of our other DOE project (Class II, Michigan Basin), and are fully operational for that state. Once a basemap and land grid for the state of California is set up in GeoGraphix, surface data can be displayed on any California maps that we make. Production data for all of the wells in the Pioneer Field area were acquired

from the California Division of Oil and Gas and will be loaded into GeoGraphix for display as overlays on structure contour and other maps.

B. Watkins continues to develop the Multimedia Database Manager shell/interface for data archiving and presentation using Microsoft Visual Basic 3.0. Interim results for this project were recently written to CD ROM for internal distribution. At present, it takes an experienced programmer to input information to the Database Manager. Watkins is developing an input interface called PioneerBuilder which will make it possible for anyone in the project to input any type of data or graphics to the Database Manager. With PioneerBuilder, data input will consist of calling up a List Box of Files and a List Box of Destinations, then simply clicking and dragging the files to their desired destinations. PioneerBuilder will be completed and ready for testing in a few weeks. When it is working to our satisfaction, C. Asiala will take over responsibility for inputting all data and graphics to the Multimedia Database Manager.

At the 1995 DOE Review Meeting for Fossil Energy Contractors in Oklahoma, T. Carr (U. Kansas) presented a "pseudoseismic" model that is based on the precept that well logs can be substituted for seismic traces in visualization software and then analyzed as if they were seismic data. We purchased the numerical computation and visualization software package MATLAB and input several gamma-ray logs for a trial run. A "pseudoseismic" cross section was generated and results were encouraging.

1.2 ORGANIZATION AND MANAGEMENT

The management tasks have gone smoothly this quarter. Subgroups met and worked on specific tasks and subtasks. Several people joined the project this quarter. C. Asiala was hired as a part-time database programmer. M. Sivek was hired as an undergraduate assistant to help in the programming. J. Alex joined the program as a part-time computer draftsman.

1.2.1 PROJECT COORDINATION

Travel was light this quarter. Most project coordination was done by telephone and e-mail. The following trips were made:

- In July, A. Nigrini traveled to MTU to work on the basin and geochemical modeling subtasks with MTU faculty and staff.

In September, J. Allan traveled to MTU to work on the project.

1.2.2 BUDGET MANAGEMENT AND QUARTERLY REPORTS

M. Gruener and A. Hein have now assumed responsibility for daily management of the budget and expenditures. A. Hein is responsible for preparation of quarterly financial reports and for distribution of 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

All of the well logs which will be used in this project are now digitized, corrected, plotted on uniform scales, and hung on the same datum. Preliminary correlations have been made and a network for structural and stratigraphic cross sections has been laid out through the study area. Two cross-sections have been completed and three more are under construction, with more to follow later.

The top of the Etchegoin Formation and the top of the Miocene have been correlated from the logs, and the top Miocene has been mapped. Fault-trace data was digitized and will soon be loaded in GeoGraphix and integrated with the formation-top data, allowing the Pioneer structure to be remapped and visualized with faults.

A new effort was initiated during the quarter. J. Alex digitized the surface geological maps of the southern San Joaquin Valley prepared by Dibblee of the California Division of Mines and Geology and loaded them into the computer drafting program Canvas, where he edited them, combined them into one large map, and colored them. When complete, the integrated map will be printed in large format on our new HP650C color plotter. Not only will this map be useful to the project, it will likely prove popular with the Bakersfield geological community.

2.1.1 LOG DATABASE MANAGEMENT

All well log calibration and analysis has, to date, been performed at DPI in the Crocker Data Processing Petrolog Program. Last quarter, digitized log data was also loaded into the TerraSciences log evaluation package at MTU and some preliminary evaluations of the program were performed. This quarter, several well logs were loaded into MTU's GeoGraphix log evaluation module, QLA2, where they were displayed on cross sections. Although its analytical capabilities are less sophisticated than Petrolog or TerraSciences, it appears that QLA2 will be very useful for producing polished log displays and cross sections.

2.1.2 LOG DIGITIZATION

Digitization of all of the wells which will be used to construct maps and 3D visualizations of the Miocene reservoir on Pioneer Anticline is complete. This includes five additional "regional" wells that were added to the database this summer.

2.2 CORE AND SAMPLE ACQUISITION

2.2.1A CORE AND CUTTINGS

Our conventional and sidewall core library of samples is now essentially 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 possession. Analyses this summer focused on the Gary Drilling Co. KLC 44 well.

2.2.1B ARCO/UNOCAL CORE

Conventional cores and core analysis data from the UNOCAL McKittrick Front Nos. 415 and 418 wells in Cymric Field have been in our possession for some time. ARCO has divested its interests in the Pioneer area, so core from their wells may no longer be available. However, the cores and core data from the two McKittrick Front wells are so outstanding that acquiring data from additional wells is probably unnecessary.

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. The database is currently being organized in Microsoft Access. As soon as a California base map has been gridded and input to GeoGraphix, the well locations for all California wells which contain brine analyses will be plotted on the basemap.

TASK 3. DATA ANALYSIS AND MEASUREMENT

3.1 PETROPHYSICS

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 conventional-core 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 will be used to analyze existing logs and produce computed logs in uncored wells which penetrate the same stratigraphic intervals on the Pioneer Anticline.

3.1.1 KPF MEASUREMENTS

Conventional core data were acquired for the UNOCAL McKittrick Front and the Tenneco 62x-30 wells. Sidewall core data is available for several additional wells.

3.1.2 FTIR SPECTRA

FTIR spectral analyses and ICP chemical analyses were completed on a suite of mineral standards by graduate student N. Popko. Data reduction is now beginning. Spectral data from standards will be input to MATLAB, a numerical computation and visualization software package, which will generate non-negative least-squares (NNLS) fits to the data. ICP elemental analyses will be converted to oxides, and mineralogies will be calculated and used to cross-check the FTIR results. When the FTIR technique is perfected, it will be applied to core and cuttings samples and used for

the identification of mineral assemblages. Popko is doing this work as his Master's research under the direction of W. Pennington.

3.2 PETROLOGY

3.2.1 XRD

XRD work this quarter concentrated on the cuttings samples from Pioneer Field. Better methods were developed for removing drilling mud from the samples. Reports were prepared that describe in detail the sample preparation procedures and the analyses performed to date on the Pioneer cuttings samples and the core samples from the Cymric McKittrick Front 415 and 418 wells. One experienced technician, R. Kramer, left the project to assume a full-time position in another department at MTU. We will attempt to cover her responsibilities by hiring graduate students and staff to continue the analytical work.

J. Ryan at the University of South Florida completed chemical analyses of selected samples from the McKittrick Front sample set using Inductively Coupled Plasma Spectroscopy (ICP).

3.2.2 SEM/IMAGE ANALYSIS

We have made arrangements with J. Boles of UC Santa Barbara to continue the image analysis work begun by Kramer.

3.2.3 PETROLOGY

Optical petrographic analyses are complete for the 44 thin sections which have been prepared to date. Results include petrographic descriptions, 35mm slides, and 35mm prints of thin sections which are characteristic of each lithologic type. Additional work will be performed as necessary.

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 will be scanned into the Multimedia Database Manager, where they can be readily accessed on hard disk and eventually on CD ROM.

3.3 LOG CALIBRATION

Data preparation and log calibration were completed on the 13 wells in the nine-section Pioneer Field area plus the 2 McKittrick Front wells.

3.3.1 DATA PREPARATION

Data preparation is complete for the 45+ wells in the original Pioneer Anticline study area. Five additional "regional" wells were added to the data set to extend our picture of the Anticline

up-plunge to the west. A spreadsheet listing all of the wells in the study, log depths and corrected subsea depths of the top of the Miocene in each well, and coordinates of the surface locations of the wells and the locations of the intersections of deviated wellbores with the top of the Miocene are listed in Table 1.

3.3.2 MODEL SELECTION

Preliminary model selection was completed for all 13 wells in the nine-section Pioneer area plus the 2 McKittrick Front wells. Results curves were generated for these wells. The results curves are calculated curves showing lithology, % clay, % shale, matrix type, porosity, and S_w . Calculation of results curves for the remaining wells with modern log suites is continuing.

TASK 4. MODELING

4.1 GEOCHEMICAL MODELING

The geochemical modeling program CHILLER is being used 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. Investigations of the feasibility of porosity prediction using CHILLER are continuing.

4.1.1 GEOCHEMICAL MASS TRANSFER

During this quarter, CHILLER was used extensively by J. Suchoski in another DOE project in which several of our members are participating (Class I, Eugene Island). Although the results are not directly applicable to this project, the experience gained will be useful in our upcoming studies of the Pioneer reservoirs.

4.1.2 THERMODYNAMIC DATABASE

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. Work will soon begin on expanding the isotope database to include hydrogen, carbon, and sulfur isotopes, and on developing a suitable model for carbon isotope fractionation.

4.2 BASIN MODELING

During this quarter, two software packages, BasinMod and Access.basin, were acquired and installed in the Subsurface Laboratory at MTU.

4.2.1 GEOHISTORY

One dimensional basin modeling activities were initiated this quarter with an analysis of Elk Hills 934-29R in the Naval Petroleum Reserve, the deepest well (24,442 feet) in the San Joaquin Valley. This well is unique in that it bottoms in Cretaceous sediments, thus giving us as complete a Tertiary section in the sub-surface as has been found to date. The 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. In addition, estimates of the surface temperature history are available as determined from water depth information derived from abundant fossil evidence. A generalized paleo-heat flow model 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. The predicted Ro value at the base of the well, on the assumption that the downhole temperature data represent the regional temperature field, is 2.4 compared to the observed value of 1.56. As vitrinite is believed to equilibrate relatively rapidly, the results indicate that the observed temperature profile is not in equilibrium with the regional temperature field in this region. In fact, examination of the complex structure of the Elk Hills reservoirs, which includes en echelon anticlines, transform, normal and reverse faults (suggestive of a flower structure), numerous discrete pressure compartments with differing temperature profiles, and recent seismic and tectonic activity suggests that the observed temperature fields at Elk Hills are not likely to be in equilibrium but are reflective of migrating geothermal fluids that have been released episodically in the very recent past up to the present day.

A present-day downhole temperature profile was calculated to be consistent with the observed Ro values. The assumption was made that Ro values have been minimally influenced by the observed non equilibrium temperature profile and still reflect the true regional temperature history. The predicted downhole temperature at 23,800 feet is 188°C compared to an observed value of 218°C. In order to match both the Ro and temperature data in the well (Figure 1), a recent heating event starting within the last 50,000 years was used. This heating is probably caused by recent movements along the many faults throughout the Elk Hills structure which lead to release of geothermal fluids from depth in the overpressured hydrocarbon generation compartments. Figure 2 is a Geohistory diagram for the Elk Hills area showing that Kreyenhagen and Tumey Formation source rocks may still be in the late oil generation window. Therefore any reservoir rocks 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.

The concept of elevated temperature profiles due to episodic release of geothermal fluids is not new. It is reflected in the oxygen isotopic compositions of vein calcite cements collected from core that show elevated isotope temperatures indicative of upwelling fluids. This phenomenon is

also observed at North Coles Levy Field to the north. A paper describing the burial and temperature history of the 934-29R well is currently in preparation.

4.2.2 2D AND 3D BASIN MODELS

The following basin modeling programs were acquired over the summer and are being tested at MTU:

BasinMod - 1-D Basin Modeling Software: The BasinMod system provides users with a relatively simple, user-friendly method for modeling the evolution of single wells. Multiple well histories can also be modeled to investigate variations in basin evolution that occur from one geographic locality to another. BasinMod allows modeling of burial histories, temperature histories, compaction, lithologies, heat flow, hydrocarbon maturities, and pressures, and allows for multiwell mapping of variables. BasinMod was acquired and installed on a PC in the Subsurface Laboratory at MTU. A. Nigrini used BasinMod to model the deepest well in the San Joaquin Basin (see Subtask 4.2.1).

Akcess.basin - 2-D, 3-D Basin Modeling Software: Earlier this summer, Access.basin was acquired and installed on the Sun Workstation in the Subsurface Laboratory at MTU. This software uses a finite-element formulation to examine the effects of thermal processes (conduction, convection, advection), fluid flow processes (compaction-driven, hydraulic-head driven), sealing mechanisms, and sedimentation/erosion during the development of a sedimentary basin. The program also predicts hydrocarbon generation (timing, location, and rate) and migration patterns. An older 3D version is now running. The latest upgrade was recently received, but requires debugging before it can be used.

TASK 5. TECHNOLOGY TRANSFER

5.1 REPORTS

To date, the main technical reports prepared and distributed have been quarterly technical reports to DOE and internal progress reports. 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

Project Workshop

Work has begun on a Manual for a Project Workshop. The Manual will be used as the text for a course which will be first presented in Bakersfield, CA, probably in the fall of 1996. Previously, we had discussed initiating our technology transfer effort with a smaller workshop on database design and construction. We have now decided to discuss databases as a subsection of a larger workshop that covers the entire project. J. Wood issued a memo in September, 1995, which provided an outline for the workshop and course notes, created teams and appointed team leaders

for each task, set goals for the content of each section, and established deadlines. The memo and a spreadsheet summarizing the division of responsibilities are appended as Attachment 1.

Multimedia Presentations on CD-ROM

During this quarter, the current contents of the Multimedia Database Manager were written to CD ROM. The CD's are now available for use in presentations.

Table 1

API	S	T	R	WELL	LEASE	OPERATOR	Surface Coordinates		FIELD	DATE	KB	GL	TD	LOG	LOG	DIRECT	TOP MIOCENE		OFFSET			TOP MIOCENE		
04-029							N	E						TOP	BASE	DRILLED	DD	SS	Z	NS	EW	N	E	
0370300	19	11N	22W	37	KCL 24	Standard (Chevron)	555,833	1,819,375		04-Apr-46	1032		5152	200			3797	-2765	0	0	0	555833	1819375	
2025000	19	11N	22W	4	KCL-San Emidio	Western Gulf (Chevron)	554,859	1,819,524		01-Oct-46	1059	1047	3818	20			1405	-346	0	0	0	554859	1819524	
2125001	19	11N	22W	4RD	KCL-San Emidio	Western Gulf (Chevron)	554,859	1,819,524		01-Oct-46	1056	1047	3208	20		X-	1405	-349	0	0	0	554859	1819524	
1539100	19	11N	22W	25-19	San Emidio A	Richfield (ARCO)	557,118	1,818,714	Los Lobos	24-Mar-55	980		6958	450		X-M	6835	-5855	0	0	0	557118	1818714	
1539101	19	11N	22W	25-19RD1	San Emidio A	Richfield (ARCO)	557,118	1,818,714	Los Lobos	07-Apr-55	980		6780	6300		X-M	--		0	0	0			
0143000	19	11N	22W	35-19	San Emidio A	Richfield (ARCO)	558,947	1,819,416	Los Lobos	07-Dec-54	988		6815	370		X-	6541	-5555	0	0	0	556947	1819416	
0143001	19	11N	22W	35-19RD1	San Emidio A	Richfield (ARCO)	558,947	1,819,416	Los Lobos	26-Dec-54	986		6858	5790		X-			0	0	0			
0143002	19	11N	22W	35-19RD2	San Emidio A	Richfield (ARCO)	558,947	1,819,416	Los Lobos	09-Jan-55	986		6706	6736		X-			0	0	0			
0143100	19	11N	22W	45-19	San Emidio A	Richfield (ARCO)	556,784	1,820,112	Los Lobos	23-Nov-54	983		6815	362		X	6636	-5653	0	0	0	556784	1820112	
0143101	19	11N	22W	45-19RD1	San Emidio A	Richfield (ARCO)	556,784	1,820,112	Los Lobos	23-Nov-54	983		6688	362		X	--		0	0	0			
0143102	19	11N	22W	45-19RD2	San Emidio A	Richfield (ARCO)	556,784	1,820,112	Los Lobos	23-Nov-54	983		6760	362		X	--		0	0	0			
	19	11N	22W	46X-19	San Emidio A	Western Continental	556,668	1,820,436	Los Lobos	10-Jan-93	990	978	6898			X	--							
	19	11N	22W	46X-19RD	San Emidio A	Western Continental	556,668	1,820,436	Los Lobos	10-Jan-93	990	978	6808			X	6725	-5737	-71	31	-4	556668	1820432	
0143200	19	11N	22W	58-19	San Emidio A	Richfield (ARCO)	556,689	1,820,804	Los Lobos	01-Oct-54	982		6830	350		X	6708	-5728	-2	4	55	556683	1820859	
0143300	19	11N	22W	68-19	San Emidio A	Richfield (ARCO)	556,583	1,821,461	Los Lobos	03-Sep-54	974		6438			X	6670	-5696	0	0	0			
0143301	19	11N	22W	66-19RD	San Emidio A	Richfield (ARCO)	556,583	1,821,461	Los Lobos	03-Sep-54	974		6840			X-			0	0	0			
0143400	19	11N	22W	76-19	San Emidio A	Richfield (ARCO)	556,400	1,822,108	Los Lobos	24-Jul-54	972	960	6958	380		X	6635	-5664	-1	8	54	556408	1822108	
	19	11N	22W	86-19	San Emidio A	Richfield (ARCO)	556,383	1,822,784	Los Lobos	09-Mar-54	967	955	7070	400			6665	-5699	-1	33	25	556416	1822809	
	19	11N	22W	86-19RD1	San Emidio A	Richfield (ARCO)	556,383	1,822,784	Los Lobos	09-Mar-54	967	955	6829	400		X			0	0	0			
	19	11N	22W	86-19RD2	San Emidio A	Richfield (ARCO)	556,383	1,822,784	Los Lobos	09-Mar-54	967	955	6825	400		X-			0	0	0			
	19	11N	22W	SWD-2	San Emidio A	Tenneco (ARCO)			Los Lobos										0	0	0			
UNKNOWN	20	11N	22W	56-20	CCMO	Tenneco (ARCO)	556,357	1,826,017	Los Lobos	23-Jul-58	924	911	8370	450		X	--		0	0	0			
UNKNOWN	20	11N	22W	57-20	CCMO	Tenneco (ARCO)	555,517	1,826,121	Los Lobos	07-Jan-53	953	944	6870	350		X-	6750	-5797	0	0	0	555517	1826121	
UNKNOWN	20	11N	22W	58-20	CCMO	Tenneco (ARCO)	555,168	1,825,457	Los Lobos	01-Feb-54	983	954	6860	350			6653	-5692	-2	54	22	555222.31	1825478	
UNKNOWN	20	11N	22W	58-20RD1	CCMO	Tenneco (ARCO)	555,168	1,825,457	Los Lobos	12-Mar-54	983	954	6777	5250		X			0	0	0			
UNKNOWN	20	11N	22W	67-20	CCMO	Tenneco (ARCO)	555,813	1,826,929	Los Lobos	26-May-53	929	920	7520	350		X	7475	-6548	0	0	0	555813	1826929	
UNKNOWN	20	11N	22W	78-20	CCMO	Tenneco (ARCO)	555,174	1,827,450	Los Lobos	03-Oct-82	948	938	7259	350		X	6753	-5805	0	-32	-1	555142	1827449	
1539800	20	11N	22W	85-20	CCMO	Tenneco (ARCO)	556,810	1,827,807	Los Lobos	06-Aug-54	872	859	10414	530	10322			10065	-7193	0	0	0	556810	1827807
1539800	20	11N	22W	85-20	CCMO	Tenneco (ARCO)	556,810	1,827,807	Los Lobos	11-Jul-56	872	859	9395	7016	9384			--		0	0	0		
	20	11N	22W	87-20	CCMO	Tenneco (ARCO)	555,839	1,828,098	Los Lobos	06-Sep-53	907	898	8159	500	8155			7700	-6793	0	0	0	555839	1828098
0143600	20	11N	22W	17-20	San Emidio A	Richfield (ARCO)	556,107	1,823,448	Los Lobos	16-Jun-54	964	952	6840	360		X	6640	-5680	-4	-8	55	556099	1823503	
0143700	20	11N	22W	27-20	San Emidio A	Richfield (ARCO)	556,013	1,824,126	Los Lobos	22-Oct-53	958	949	7246	350			6830	-5872	0	0	0	556013	1824126	
0143701	20	11N	22W	27-20RD1	San Emidio A	Richfield (ARCO)	556,013	1,824,126	Los Lobos	13-Dec-53	958	949	6859	350		X-			0	0	0			
0143702	20	11N	22W	27-20RD2	San Emidio A	Richfield (ARCO)	556,013	1,824,126	Los Lobos		958	949	7246	5090		X-	--		0	0	0			
0143800	20	11N	22W	37-20	San Emidio A	Richfield (ARCO)	555,657	1,824,770	Los Lobos	15-Feb-55	967	955	6770	500		X	6655	-5689	-1	4	53	555661	1824823	
1539200	20	11N	22W	47-20	San Emidio A	Richfield (ARCO)	555,823	1,825,195	Los Lobos	11-Jul-53	951	942	6820	501		X-	--		0	0	0			
UNKNOWN	21	11N	22W	18-21	LLU	Richfield (ARCO)	555,109	1,828,928	Los Lobos	27-Jun-52	913	901	8008	550			7250	-6337	0	0	0	555109	1828928	
UNKNOWN	21	11N	22W	38-21	LLU	Richfield (ARCO)	555,185	1,830,085	Los Lobos	15-Apr-53	916	907	7893	360			7824	-6908	0	0	0	555185	1830085	
0052000	21	11N	22W	48-21	LLU	Richfield (ARCO)	555,403	1,830,727	Los Lobos	26-Aug-58	904	891	8500	540		X	8340	-7436	0	0	0	555403	1830727	
	21	11N	22W	1	San Emidio	Shel (SWEPI)							4826						0	0	0			
UNKNOWN	21	11N	22W	27-21	San Emidio	Richfield (ARCO)	556,139	1,829,138	Los Lobos	05-Mar-54	877	866	9110	660		X	9020	-8143	0	0	0	556139	1829138	
3617700	27	11N	22W	12-27	KCL	MACPET	553,876	1,833,993	Los Lobos	04-Mar-61	968	955	7903	360		X	7825	-8657	0	0	0	553876	1833993	
3712400	27	11N	22W	M1	KCL	Conoco	552,584	1,836,728		17-Oct-47	1041	1029.5	8331	1000				7890	-6819	0	0	0	552584	1836728
0197900	27	11N	22W	13-X	KCL	Kenneth Sperry	553,153	1,834,276	Los Lobos	13-Jan-67	1009	996	6982	6934			6934	-5925	0	0	0	553153	1834276	
1538400	27	11N	22W	34-27	San Emidio A	Richfield (ARCO)	552,590	1,835,733		11-Jan-52	1034	1022	7284	720		X	7140	-6106				552590	1835733	
1538400	27	11N	22W	34-27RD	San Emidio A	Richfield (ARCO)	552,590	1,835,733		11-Jan-52	1034	1022	6624	720		X								
	27	11N	22W	26-27	Santiago D	Tenneco (ARCO)	551,200	1,834,780		15-Jun-81	1068	1103	6739	52			4577	-3489	0	0	0	551200	1834780	
0370400	28	11N	22W	1	KCL 3	Standard (Chevron)	554,589	1,830,788	Midway-Sunset	1924	938	937.67	5663				--		0	0	0			
UNKNOWN	28	11N	22W	41-28	LLU	Richfield (ARCO)	554,531	1,830,752	Los Lobos	21-Feb-53	945	936	7204	510			7195	-6250	0	0	0	554531	1830752	
1539400	28	11N	22W	11-28	San Emidio A	Richfield (ARCO)	554,404	1,828,838	Los Lobos	06-May-55	948	934	7084	655		X	6811	-5884	-1	52	62	554456	1828900	
1539401	28	11N	22W	11-28RD1	San Emidio A	Richfield (ARCO)	554,404	1,828,838	Los Lobos	11-Jun-55	948	934	6980	6260		X	--		0	0	0			
1538500	28	11N	22W	25-28	San Emidio A	Richfield (ARCO)	551,869	1,828,338	Los Lobos	27-Apr-53	1048	1037	3310	350			3200	-2152	0	0	0	551869	1828338	
1539500	28	11N	22W	61-28	San Emidio A	Richfield (ARCO)	552,464	1,832,052	Los Lobos	01-Dec-53	953	942	8256	530		X	8191	-7239	-1	-10	68	552454	1832120	
1539501	28	11N	22W	81-28RD	San Emidio A	Richfield (ARCO)	552,464	1,832,052	Los Lobos	01-Dec-53	953	942	8225	530		X	--							
1539600	28	11N	22W	62-28	San Emidio A	McPharlin	553,649	1,832,082	Los Lobos	20-Sep-55	982	969	7100	419		X	6880	-5903	-5	-95	98	553654	1832180	
1539601	28	11N	22W	62-28RD	San Emidio A	McPharlin	553,649	1,832,082	Los Lobos	20-Sep-55	982	969	6515	419		?	--		0	0	0	553654	1832180	
1539700	28	11N	22W	82-28	San Emidio A	McPharlin													0	0	0			
1539800	28	11N	22W	84-28	San Emidio A	Richfield (ARCO)	552,524	1,833,431		14-Jan-51	1041	1020	7200	740			5550	-4509	0	0	0	552524	1833431	
1539801	28	11N	22W	84-28RD	San Emidio A	Richfield (ARCO)	552,524	1,833,431		14-Jan-51	1041	1020	5378	740		X	--		0	0	0			
6199400	28	11N	22W	55-28	Santiago C	Tenneco (ARCO)	551,888	1,831,421	Los Lobos	28-Aug-80	1068	1053	5000	800			3623	-2555	0	0	0	551888	1831421	

	30	11N	22W	82X-30	Los Lobos	Tenneco (ARCO)			Los Lobos	25-May-81	1061	1050	2702	318				1061	0	0	0	0	0
6436400	30	11N	22W	82X-30	Los Lobos	Tenneco (ARCO)	553,618	1,622,726		27-May-81	1065		2700				1292	-227	0	0	0	553618	1622726
6508400	30	11N	22W	65-30	Muddy Creek A	Tenneco (ARCO)	551,868	1,621,486		29-Jul-81	1142.9	1131.9	4000	700			1234	-91.1	0	0	0	551868	1621486
6548500	30	11N	22W	76-30	Muddy Creek	Tenneco (ARCO)	551,208	1,622,226		22-Oct-81	1162.6	1152.6	2000	90			1174	-11.4	0	0	0	551208	1622226
	30	11N	22W	72-30	Santiago A	Tenneco (ARCO)	553,848	1,622,146	Los Lobos	24-Sep-80	1063	1048	3503	850			1367	-304	0	0	0	553848	1622146
2124600	31	11N	22W	3	KCL San Emigdio	Western Gulf (Chevron)	547,862	1,620,896		30-Sep-46	1318.9		4019				519	799.9	0	0	0	547862	1620896
2121500	31	11N	22W	3-A	KCL San Emigdio	Western Gulf (Chevron)													0	0	0		
2385400	31	11N	22W	1	Morrison	Union (Unocal)	549,212	1,618,072			1287		2070				385	902	0	0	0	549212	1618072
	31	11N	22W	Core Hole		Shell (SWEPI)													0	0	0		
1371200	31	11N	22W	76-31	Union	Shell (SWEPI)	545,896	1,622,269		23-May-39	1348		4314	670	4026		1184	164	0	0	0	545896	1622269
UNKNOWN	32	11N	22W	2		Texaco							3533						0	0	0		
	32	11N	22W	8-32	KCL-1A	Shell (SWEPI, Cal Resources)	544,582	1,623,581		19-Apr-39	1351.8	1552	4870	670			1442	-90.2	0	0	0	544582	1623581
0940400	32	11N	22W	12	KCL 44	Standard (Chevron)	548,553	1,623,540	Pioneer	04-Jan-60	1248	1240	5350	22	5349		800	448	0	0	0	548553	1623540
0940500	32	11N	22W	23	KCL 44	Standard (Chevron)	547,893	1,624,200	Pioneer	10-Dec-59	1258	1242	4835	32	4831		937	321	0	0	0	547893	1624200
0940600	32	11N	22W	25	KCL 44	Standard (Chevron)	546,565	1,624,225	Pioneer	29-May-64	1290	1282	4330	20	4323		870	320	0	0	0	546565	1624225
0940700	32	11N	22W	32	KCL 44	Standard (Chevron)	548,553	1,624,860	Pioneer	28-Dec-59	1209		4760	29	4755		1160	49	0	0	0	548553	1624860
0940800	32	11N	22W	34	KCL 44	Standard (Chevron)	547,233	1,624,860	Pioneer	28-Jun-59	1258		10022	400			1037	221	0	0	0	547233	1624860
0940801	32	11N	22W	34RD1	KCL 44	Standard (Chevron)	547,233	1,624,860	Pioneer	29-Jun-59	1258		4030			X-			0	0	0		
0940900	32	11N	22W	43	KCL 44	Standard (Chevron)	547,893	1,625,520	Pioneer	18-Nov-59	1212	1204	5851	20			1212	0	0	0	0	547893	1625520
0941000	32	11N	22W	45	KCL 44	Standard (Chevron)	546,604	1,625,542	Pioneer	05-Oct-59	1258	1250	4325	28	4321		1093	165	0	0	0	546604	1625542
	32	11N	22W	375X	KCL 44	Gary Drilling Co.	546,784	1,626,817	Pioneer	04-Jul-60	1216.3	1206.3	3211	550			1282	-65.7	0	0	0	546784	1626817
3615300	32	11N	22W	1	Pioneer	Milham Exploration Co.	547,543	1,623,960	Pioneer	08-Jun-26	1260		1506				917	343	0	0	0	547543	1623960
0368200	33	11N	22W	55-33	KCL	Standard (Chevron)	546,565	1,626,157		05-Dec-64	1304.86	1296.86	2700	502			2480	-1175.1	0	0	0	546565	1626157
3615600	33	11N	22W	2	Pioneer	Milham Exploration	546,533	1,628,756		31-Aug-26	1226	1226	1758				1578	-352	0	0	0	546533	1628756
2365500	33	11N	22W	C-2	San Emidio	Union (Unocal)	545,587	1,628,508		12-Apr-37	1265	1265	1839	47	1830		1580	-315	0	0	0	545587	1628508
2365600	33	11N	22W	C-3	San Emidio	Union (Unocal)	547,898	1,628,640		28-Apr-37	1109		3226				1821	-712	0	0	0	547898	1628640
3529800	34	11N	22W	18-34	KCL	Occidental Pet. Co.	544,594	1,634,151		29-Jun-64	1393.2	1381	8791	1047			3120	-1726.8	0	0	0	544594	1634151
2124700	34	11N	22W	1	KCL San Emigdio	Western Gulf (Chevron)	545,919	1,634,151	Los Lobos	26-Nov-45	1330.3	1328.84	3548	40			3139	-1808.7	0	0	0	545919	1634151
2385700	34	11N	22W	C-1	San Emigdio	Union (Unocal)	547,728	1,636,223		26-Mar-37	1222		4805	17	4797		4335	-3113	0	0	0	547728	1636223
36016	25	11N	23W	41	Ripley	C.Ray Robinson			Midway-Sunset	02-Dec-53	1084		7509	50	7500								
	25	11N	23W	44	Ripley	Norbel Oil			Midway-Sunset	18-Jul-55	1152		2010	50	2010								
97523	25	11N	23W	1	Ripley Trust	Arcady Oil			Midway-Sunset	16-Dec-72	1113	1101	5812	100	5600		X						
48632	25	11N	23W	2	Ripley Trust	Lawbar Petroleum			Midway-Sunset	06-Apr-74	1101	1091	4500	50	4500								
48632	25	11N	23W	2RD	Ripley Trust	Lawbar Petroleum			Midway-Sunset	24-Feb-76	1101	1091	4090	550	4090		X						
49672	25	11N	23W	3	Pyramid-Ripley Trust	Montara Petroleum			Midway-Sunset	17-Sep-74	1080	1070	3750	50	3740								
36546	25	11N	23W	1	Santiago	Robt.W. Moore			Midway-Sunset	16-Sep-56	1237		1200	150	970								
	25	11N	23W	8		Western Minerals			Midway-Sunset	30-Nov-09	1209		2050										
36654	25	11N	23W	37-25	Western Minerals	Tidewater Assoc.			Midway-Sunset	24-Mar-42	1213		1700	170	1700								
53172	26	11N	23W	1	Montara-McFarland	McFarland Energy			Midway-Sunset	10-Sep-76	1160	1170	1585	180	1570								
	26	11N	23W	12		Western Minerals			Midway-Sunset	25-Feb-11	1175		903										
01300	35	11N	23W	1	USL-Woodward	Pauley Petroleum			Midway-Sunset	08-Feb-67	1200	1185	13131	100	13090								
89488	36	11N	23W	1-36	ARCO	Stone Exploration			Midway-Sunset	30-Oct-91	1344	1330	4217										

Figure 1. A plot of temperature and maturity (R_o) as a function of depth in Elk Hills 934-29R. Solid lines represent calculated values derived after calibrating formation thermal conductivities and heat flow history to achieve a match with the observed data shown as crosses.

Elk Hills (EH)

29RDELT.MOD

EH 934-29R

Figure 1

Figure 2. A geohistory diagram for the Elk Hills 934-29R well showing isotherms and the oil window (see legend) as defined by vitrinite reflectance kinetic modeling. The bold hatched area at the top of the diagram represents sea depths.

EIK HILLS (EH)

29RDELT.MOD

EH 934-29R

Figure 2

Memorandum

To: All DOE California Project Participants:
DPI: R. Berry, D. Olson
MTU: J. Allan, C. J. Asiala M. Gruener, A. Hein, J. Huntoon, Ming Luo, D. McDowell, A. Nigrini, D. Schueller, J. Suchoski, W. Pennington, N. Popko, B. Watkins

From: J. R. Wood

Date: September 5, 1995

Subject: Manual for Project Workshop

I am circulating the first draft of the course outline for our California project on the Pioneer Anticline as well as a timeline for this aspect of the project. The course outline contains assignments for the people to be responsible for various parts of the course manual either as the lead person or as part of the team that will work on that particular section. Locate your sections on the outline and on the timeline. I have already discussed these assignments with most of you already, but if I have missed someone or you wish to make changes, contact me as soon as possible.

The 1st short course will likely be offered in Bakersfield, Ca. in the fall of 1996. A final date and venue will be adopted this winter at our annual meeting.

I have a suggested number for the minimum or maximum number of pages of text (1 1/2 line spacing, 8 1/2 x 11) as well as a suggested number of figures. The lead person in each section should contact the team members and finalize these numbers by Oct. 1. Respond either to me or Mark Gruener at MTU (906-487-2894).

There is also a column in the manual outline that says "TIME" in minutes. This is the suggested time allotted for your presentation(s) at the workshop. If you need more or less time, let us know by Sept. 1. Note that the total time allotted as of now is about 695 minutes, which is about right for a two-day short course.

Note that the total number of text pages is presently estimated at between 365 and 511 pages, which again I think is about right. The number of figures is estimated at 259, which comes out to about 2.68 minutes per figure, which also strikes me as about right. If anyone thinks these estimates are seriously in error, please call me and let's discuss it ASAP.

SOME HELPFUL HINTS

1. I strongly suggest to everyone that you organize your text and presentations around your figures. In other words, get your figures organized first, even if they only exist as captions or sketches. **Please submit your figures (even as sketches) and captions by Jan. 1, 1996.** Sooner if possible. See the timeline.

2. Plan to **submit your finished text by March 1, 1996**. Even is your task is not finished, try to submit a text that is as finished as possible. You can leave room for additions.
3. Try to draft as many figures as possible electronically. Figures printed from LOTUS 1-2-3, MS Access etc. will be fine. For more complicated drafting, I suggest CANVAS or Corel Draw. MATLAB might be a good choice as well since we are starting to use that product in the visualization task. If you need figures from GEOGRAPHIX, let us know and we will work with you to get it done.
4. The manual will be edited and printed using LOTUS AmiPro. Please submit electronic copy compatible with this word processor.
5. Everyone will be listed as an author on the appropriate chapter(s). I will be the editor. We will try to get the manual published as a peer reviewed publication, but that may not be practical for the first short course. Eventually you will be able to cite your work and include it in your vita.
6. We have plans to put the manual on the Project CD ROM. If all goes well, you may be able to project material from this ROM onto the screen during your presentations. However, plan your presentations as though you will only have an overhead projector and a 35 mm projector at your disposal.
7. You can probably use the material you develop for the short course for part or all of your final report with some reformatting and editing. So keep that in mind. I will issue a call for your final report sometime this spring.
8. We will have another **annual meeting** this January, 1995, probably in Bakersfield, California. We will review progress on this manual at that time.

I feel we have an opportunity to turn out an excellent publication that will be useful to the industry and will fulfill the DOE objectives. It is important that every one focus on this task and move it to the top of your priority lists. Everyone has done very well so far in the tasks and I think things are coming together nicely. As we prepare this manual, I think you will see how things fit together and how much has been done.

DOE VISUALIZATION PROJECT ON PIONEER ANTICLINE

OUTLINE FOR WORKSHOP MANUAL	LEAD	TEAM	# Pages		Minutes	# Figures
			MIN	MAX		
INTRODUCTION	JRW	ALL	5	8	15	4
WELL LOGS	DPI	AN & JRA				
DATA CAPTURE					30	10
Digitize logs			5	8		
Digitize Well Locations, Mechanical Data, Header Data			3	5		
Digitize Reservoir Data (Core, Rock and Fluid Data)			3	5		
'Digitize Production Data			1	2		
DATA PREPARATION					45	10
Build Log Database (Edit, Depthshift, Environ. Corrections)			6	8		
Build Cross Sections			3	5		
Build Base Maps			3	5		
DATA ANALYSIS					45	10
Interpretation			5	8		
Correlation			3	5		
Mapping Reservoir Properties						
Porosity			1	2		
Permeability			1	2		
Lithology			1	2		
Oil Saturation			1	2		
REPORTING					45	10
Methodology			3	5		
Case history - Pioneer Field			8	10		
LOG VISUALIZATION					45	10
Export Data			3	5		
Demonstrations of Applications			20	25		
LAB MEASUREMENTS						
SOLIDS						
X-Ray Diffraction	DCP	SDM	15	20	20	10
FTIR	DCP		15	20	20	10
Bulk Composition	DCP		15	20	20	10
SEM	DCP	SDM	15	20	20	15
Petrographic Image Analysis	JRW/JRB	SDM	15	20	20	15
FLUIDS			15	20		
Oils (Literature search; company files)	JRA	AN	10	12	20	10
Formation Waters (Lit. search; company files)	JRW	JRA;AN	10	12	20	10
VISUALIZATION						
GEOLOGY						
Maps	WDP	DPI;CJA	15	20	20	10
Cross Sections	WDP	DPI;CJA	15	20	20	10
3D Rendering ("Pseudo-seismic")	WDP	DPI;CJA	15	20	45	10
ENGINEERING (?)			20	30	45	20
MODELING						
GEOCHEMICAL						
Fluid-rock interactions (CHILLER)	AN	JRW;JPS	20	30	45	20
Thermodynamic Database	JRW	JPS;AN	10	15	20	10
BASIN ANALYSIS						
Geohistory	AN	JRW	20	30	30	10
Thermal History	AN	JRW	20	30	30	10
DATA MANAGEMENT						
PC Databases	AN	DPI	10	15	30	10
CD ROM	CJA	JRW; MJG	20	30	45	10
SUMMARY	JRW	JRA;AN;DPI	15	15		5
TOTALS			365	511	695	259