QUARTERLY REPORT

MICHIGAN TECHNOLOGICAL UNIVERSITY

APRIL, 1995

Recovery of Bypassed Oil in the Dundee Formation Using Horizontal Drains

Contract Number: DE-FC22-94BC14983

University: Michigan Technological University

Budget Period: 04-28-94 to 10-27-95

Project Period: 04-28-94 to 04-27-97

Cumulative DOE Obligation: \$800,000

Program Manager: James R. Wood (813) 974-9674

Principal Investigator: James R. Wood

Contracting Officer's Representative (COR): Chandra Nautiyal (918) 337-4409

Reporting Period: 2nd Quarter FY 1995

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

15 April 1995 10:13 AM

MASTER

RECEIVED
USDOE/PETC

95 APR 27 AM 11:22

DEPARTMENT OF ENERGY

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

EXECUTIVE SUMMARY

The following is a chronological description of project meetings and activities for the 2nd quarter FY 1995:

- Teams at WMU and MTU worked on various aspects of the project. Very significant technical contributions were made in the areas of data gathering, map and cross section construction, and log evaluation by W. Harrison and his WMU team.
- In January, 1995, all members of this project and of our California DOE Class II reservoir project met at USF in Tampa for our Annual Project Review Meeting.
- In March, 1995, project members ran a booth in the Exhibits Hall at the AAPG National Meeting in Houston. The booth included a poster display which described project goals and progress to date and a computer demonstration.
- In late March and early April, 1995, Wood and Allan met at USF in Tampa to work on the project.

Well data, including drillers' logs, wireline logs, and seismic data, from the Crystal and 30 other Dundee oil fields in the Michigan basin have been acquired. Digitized logs of 336 wells that currently produce or have produced from the Dundee Formation in the seven-county study area have been purchased from Maness Petroleum Company. The data-gathering phase of the well-log program is now complete. Well-log analysis using TerraSciences TerraStation software has begun. Detailed analyses of wells with modern logs are being made using density/porosity and Pickett crossplots. Water saturations were calculated for several wells in the past month.

Production data have been added to the well-file database. We now have the capability of mapping production as well as geology. Well-location basemaps with permit numbers were constructed for all 30 fields. Contour maps were completed for all 30 fields during the last quarter, including maps: on the top of the Dundee Formation, the top of the Dundee porosity zone (which is well below the top of the Dundee and varies in stratigraphic position throughout most fields), Dundee to Traverse isopachs, and initial production values before and after well treatment. At least two simple computer-generated cross sections were constructed for each field.

S. Chittick has completed his M.S. thesis on Winterfield Field, which possesses more modern log data than most other Dundee Fields. The purpose of the Winterfield study was to delineate possible economic zones of by-passed oil in the Dundee by characterizing the structural, stratigraphic, and lithological components of the Dundee utilizing well data (drillers' logs and scout tickets), petrophysical log data, and production data. Corrected porosity values were calculated for all wells with available CNL and density well log data using the KOBRA:XPLOTT algorithm of TerraSciences' TerraStation software, which is based on Schlumberger cross plots. Water saturation values were calculated and averaged over the top sixty feet of the reservoir.

Water saturation values were subtracted from 1 to get the oil saturation. These values were plotted as contours.

W. Harrison currently has the porosity, permeability, and oil saturation data for all of the Dundee cores from wells in a seven-county area surrounding Crystal Field in his possession. When all available core material has been identified, samples will be collected from each core. This phase of the project has just begun. Samples are being selected to provide good coverage of all of the lithofacies and porosity types present in the Dundee Formation. SEM analyses of selected samples are currently being performed.

Project personnel at WMU are using Terrasciences' TerraStation software to analyze and archive project data. The MTU group participating in another DOE project with the specific goal of developing and demonstrating an integrated system for database management and reservoir visualization. A Spatial Database Manager (SDBM) shell/interface and a Multi-Media Program (MMP) are currently being developed in this project using Microsoft Visual Basic 3.0. The SDBM is a Windows shell that provides access to an underlying database engine (Microsoft Access), a well-log interpretation program (Crocker Data Processing Petrolog), mapping and cross-section software (the GeoGraphix Exploration System Workbench) and a volume visualization application (yet to be determined). The SDBM will have the added benefit of online help and tutorial information. This system, and all of its components, is available for use in the Dundee project. We intend to use the MMP as a technology transfer mechanism. All data and information associated with the project will be stored on hard disk and will be accessible via the MMP. At the end of the project, all data, graphics, tutorials, manuals, etc., will be stored on CD ROM for distribution to DOE and to our target audience within the petroleum industry.

Drilling was delayed pending completion of an environmental site assessment. Terra Energy was reluctant to commence drilling before receiving a covenant from the Department of Natural Resources, State of Michigan, protecting them from lawsuits for pre-existing environmental contamination. Terms of an agreement were recently agreed upon by Terra and the State of Michigan and the covenant is now awaiting signature in the Michigan State Attorney General's office. We expect that the document will soon be signed and drilling can commence in the summer of 1995. Cronus Development Corp., under contract to Terra Energy, will drill the well.

Meetings of the Michigan Oilfield Research Consortium (MOFRC), open to all interested parties, will be conducted by the project staff. Various aspects of the project will be discussed through poster or oral presentations. J. Huntoon and A. Hein have put together a newsletter which will be mailed to independent oil producers and other interested parties. The initial mailing list of potential members of the Michigan Oilfield Research Consortium is now complete.

Project members ran a booth in the Exhibits Hall at the AAPG National Meeting in Houston, March 5 to 8, 1995. Considerable interest was generated in our project. Several independents asked to be kept abreast of project developments and to have quarterly reports mailed to them. We gained the impression that if our horizontal well is commercially successful, we will have little

trouble finding independents who are interested in drilling horizontal wells in areas that coned water and left behind bypassed oil in other Dundee fields.

On January 19 and 20, 1995 we held a meeting at the University of South Florida in Tampa to review both of our DOE projects. Each project member made a presentation on his or her work. The meeting afforded project members an opportunity to learn what everyone else was doing and to discuss project plans and accomplishments in an open forum. The meeting was very successful at accomplishing these goals.

Although the Modeling Task is not scheduled to begin until the Budget Period 2, acquisition of software has begun. At present, all of the major hardware and software purchasing decisions have been made and purchases are in progress. Because the target audience for technology transfer in this project consists mainly of small independent oil exploration and production companies, price and flexibility are critically important. During the last quarter, the following purchases were agreed upon: HP650C Color Plotter, GeoGraphix Data Management and Visualization Software, BasinMod 1-D Basin Modeling Software, and Akcess.basin 2-D,3-D Basin Modeling Software.

SUMMARY OF TECHNICAL PROGRESS BY TASK

BUDGET PERIOD 1

TASK 1.1 PROJECT MANAGEMENT

This task involves the management and administration of all Budget Period I activities. The cooperative agreement requirements are being performed in conjunction with the administrative functions necessary to coordinate with producing partners, vendors, subcontractors, consultants, and suppliers. A detailed Project Management Plan encompassing both Phase I and II, including cost, labor and milestone plans was prepared in accordance with the Reporting Requirements. All required reports are being prepared and submitted to the DOE in accordance with the Reporting Requirements.

Although project members are located at four sites (Tampa, FL; Houghton, MI; Kalamazoo, MI; and Los Angeles, CA) project coordination has been very successful. Allan and Nigrini make quarterly trips to Michigan Technological University (MTU) in Houghton and occasional trips to Western Michigan University (WMU) in Kalamazoo and the University of South Florida (USF) in Tampa to work on project tasks with Wood, Harrison, Pennington, Huntoon, and their students. Wood travels from USF to MTU every 6 weeks on project business. Chittick travels to WMU on a regular basis to work with the database and core repository there. Allan and Nigrini generally meet at least every other week to coordinate their work on the project. The computer network and server at MTU is a critical link in the communications network.

Project Coordination

The following is a chronological description of project meetings and activities for the 2nd quarter FY 1995:

- Teams at WMU and MTU worked on various aspects of the project. Very significant technical contributions were made in the areas of data gathering, map and cross section construction, and log evaluation by W. Harrison and his WMU team.
- In January, 1995, all members of this project and of our California DOE Class II reservoir project met at USF in Tampa for our Annual Project Review Meeting.
- In March, 1995, project members ran a booth in the Exhibits Hall at the AAPG National Meeting in Houston. The booth included a poster display which described project goals and progress to date and a computer demonstration.
- In late March and early April, 1995, Wood and Allan met at USF in Tampa to work on the project.

1.1.2 BUDGET MANAGEMENT AND QUARTERLY REPORTS

S. Milligan reprogrammed the project budgets and has set up a system for logging, recording and archiving all invoices related to this project. She developed a convenient way to visualize the project budgets by monthly expenditures, cumulative expenditures, and projected expenditures using Lotus graphics. M. Gruener and A. Hein have now assumed responsibility for daily management of the budget and expenditures. J. Allan is responsible for quarterly and annual technical reports.

TASK 1.2 RESERVOIR CHARACTERIZATION

Well and log data sets and production data sets for all 30 fields are now complete. Tops have been picked on all formations in all wells. The well location and formation tops data sets are also now complete.

1.2.1 WELL LOG ACQUISITION, DIGITIZATION, ANALYSIS

Well-log analysis and regional geological studies are being carried out by W. Harrison and his graduate students at WMU. Well data, including drillers' logs, wireline logs, and seismic data, from the Crystal and 30 other Dundee oil fields in the Michigan basin have been acquired. Digitized logs of 336 wells that currently produce or have produced from the Dundee Formation in the seven-county study area have been purchased from Maness Petroleum Company. The data-gathering phase of the well-log program is now complete. We recently acquired several hundred old SP/Resistivity logs (mostly of the Dundee Formation) from the mid-1940's and 1950's. These are in addition to the above logs. These old logs will be digitized in the coming quarter. SP on these old logs is particularly good for calculating R_w values for formation waters.

A number of operations are being performed on selected wells to correct them. Among these operations are: a) depth-shifting, b) TVD (True Vertical Depth) and TST (True Stratigraphic Thickness) corrections, c) normalization, d) environmental corrections.

Well-log analysis using TerraSciences TerraStation software has begun. Detailed analyses of wells with modern logs are being made using density/porosity and Pickett crossplots. Water saturations were calculated for several wells in the past month.

Regional Studies

Production data has been added to the well-file database. We now have the capability of mapping production as well as geology. Well-location basemaps with permit numbers were constructed for all 30 fields. Contour maps were completed for all 30 fields during the last quarter, including maps: on the top of the Dundee Formation, the top of the Dundee porosity zone (which is well below the top of the Dundee and varies in stratigraphic position throughout most fields), Dundee to Traverse isopachs, and initial production values before and after well treatment. At least two simple computer-generated cross sections were constructed for each field. All these maps have

been plotted on 81/2x11 pages and have been compiled by field into single "folio" sized poster sheets. More detailed cross sections are being constructed on field and regional scales.

Now that we have production data for all of the fields in our database, cumulative production maps can be constructed. Interval isopach maps of top Dundee to top Dundee porosity zone (which will map the number of feet one must drill beneath the top of the Dundee to hit pay) will also be constructed. Net pay isopachs will be more difficult. Most wells are drilled to the top of Dundee porosity and completed without ever crossing the oil/water contact. Therefore the positions of oil/water contacts can only be estimated from off-structure dry holes. However, it appears that we may be able to reasonably estimate the positions of oil/water contacts in about 25% of the fields, which will allow us to construct volumetric maps for those fields. All of these maps will be constructed after completion of the basic contour maps for each field.

Pressure data is also hard to come by in many of these old fields. We expect that we will be able to produce pressure decline curves for a few wells, though, and with the volumetric maps for our most tightly constrained fields, will be able to estimate recovery factors and other engineering parameters in a few locations. These values can then be extrapolated to other fields with poor data.

Winterfield Field

S. Chittick has completed his M.S. thesis on Winterfield Field, which possesses more modern log data than most other Dundee Fields. In Winterfield Field, several wells penetrate the entire Dundee porosity zone, allowing a more thorough evaluation of the reservoir than could be done elsewhere. The purpose of the Winterfield study was to delineate possible economic zones of by-passed oil in the Dundee by characterizing the structural, stratigraphic, and lithological components of the Dundee utilizing well data (driller's logs and scout tickets), petrophysical log data, and production data.

The initial well data set used to create maps and plots was obtained from Petroleum Information Corporation (PI). Geophysical logs from Winterfield field were obtained in digital form from Maness Petroleum. Production data were obtained from the Michigan Department of Natural Resources, Geological Survey Division. Contour plots of formation tops and top porosity were constructed with CoPlot by CoHort Software.

Porous dolomite above the oil-water contact, capped by either the Bell Shale or tight Dundee limestone, is the producing lithology within the Dundee. The producing zones can be discriminated quite readily from a suite of geophysical logs containing gamma ray (GR), photoelectric log (PEF), and deep laterolog (LLD) logs. These logs can be further enhanced with the addition of the CNL and density logs to determine corrected porosity values in the producing interval. Corrected porosity values were calculated for all wells with available CNL and density well log data using the KOBRA:XPLOT algorithm of TerraSciences' TerraStation software, which is based on Schlumberger cross plots. Water saturation values were calculated and

averaged over the top sixty feet of the reservoir. Water saturation values were subtracted from 1 to get the oil saturation. These values were plotted as contours.

Cross sections of Winterfield Field illustrate the extreme variability in production that is so characteristic of these Dundee fields and show how the Dundee porosity zone varies in thickness across the field. The top of dolomite porosity drops below the oil/water contact in places, leading to discontinuities in the reservoir which may result in bypassed oil. Thus, understanding Dundee dolomitization is important to enhanced oil recovery operations.

Although Chittick has not yet been able to accurately quantify the amount of bypassed oil in Winterfield Field, potential areas for further exploration can be delineated by looking for leases that appear to be underachievers relative to structural position, initial production tests and relative production compared to surrounding areas that produce from similar lithologies. Dart Oil and Gas drilled 3 wells in the mid 1980's with the Richfield Formation as the target zone and inadvertently discovered oil in the Dundee in the western part of Winterfield Field, where reservoir quality was previously thought too poor to produce. The discovery shows that pockets of economically produceable oil still exist in this field, and perhaps in many others.

Chittick's M.S. thesis represents a major technical contribution of this project.

1.2.2 CORE ACQUISITION AND ANALYSIS

About 50 cores of the Dundee Formation from throughout the state of Michigan have been identified and are currently available in public repositories (i.e., the Western Michigan University Core Research Lab, the University of Michigan Subsurface Lab, the Wayne State University core facility, the Central Michigan University core facility, and the Michigan Geological Survey core repository in Lansing). Each of these cores will be described and samples will be taken for thin section, Xray diffraction, and SEM analyses to determine mineralogy and porosity characteristics. Cuttings samples from 60 to 100 Michigan wells are also available. Additional materials will be obtained from private sources. WMU graduate student M. Foley is using a database called COREDAT, provided to us by Maness Petroleum, to search the drillers' reports and core analysis files for cores we have missed. Analysis of selected samples from the Western Michigan University Core Research Lab has begun.

There are no cores in Crystal Field, the site of the field trial in this study. The closest Dundee core is in an outpost well 8 to 10 miles away from Crystal Field. Thus, acquisition of a good vertical core through the Dundee in Crystal Field is an essential element of the reservoir characterization study. Porosity (p), permeability (k), fluid saturation (s) and formation factor (f) data are being gathered from core analysis reports and entered into the database. P,k,s,f analyses will be performed on the core from the well drilled at Crystal Field as discussed in Task 1.4. W. Harrison currently has the porosity, permeability, and oil saturation data for all of the Dundee cores from wells in a seven-county area surrounding Crystal Field in his possession. This includes data from some cores that are no longer available to be sampled.

When all available core material has been identified, samples will be collected from each core. This phase of the project has just begun. Samples are being selected to provide good coverage of all of the lithofacies and porosity types present in the Dundee Formation. Samples from both producing and non-producing intervals will be gathered and an attempt will be made to link lithology to petrophysics, so that different "petrophysical facies" can be identified. In areas where no cores are available, drill cuttings will be sampled. Ideally, we would like to map "petrophysical facies", because this approach leads to a better understanding of lithologic controls on variability in production rate, but sample coverage is sparse in these old fields and this type of mapping may not be possible.

Xray diffraction analyses of approximately 200 samples will be performed to determine the proportion of calcite, dolomite, other major and accessory minerals. To help estimate paleotemperatures and salinities and to determine the origin of the porosity-producing dolomitizing fluid, fluid inclusion temperature and salinity measurements will be made on 40 to 60 samples. Paired oxygen-carbon isotope measurements will be made on 100 to 200 samples.

Point counts for mineralogy and porosity will be performed on approximately 60 to 100 polished thin sections of core and cuttings samples using optical methods. Identification and quantification of major mineral phases, clay mineral phases, pore space, and hydrocarbons will be determined, where possible. Conventional SEM analyses will be performed on many of these same samples, and, if needed, SEM image analysis will be used to determine shape factor and rock texture and to supplement identification of phases.

SEM analyses of selected samples from the nearest cored well to Crystal Field (Leonard Oil Co., Lee #1, Montcalm County, MI) are currently being performed by W. Harrison and his graduate students at WMU to investigate microtextures in the Dundee reservoir, including intercrystalline porosity and fractures.

1.2.3 FTIR SPECTROSCOPY

Fourier transform infrared spectroscopy (FTIR) analyses have begun. D. Popko at MTU is developing techniques for performing quantitative analyses of rock samples using FTIR as part of his M.S. thesis research. Sample preparation, accumulation of a suite of mineral standards, and development of reliable analytical techniques are critical to this endeavor. Popko has recently collected spectral data on mineral standards. Spectral data from standards will be input to a mathematical program which will generate non-negative least-squares (NNLS) fits. The NNLS fits will be applied to FTIR spectral data gathered on core samples from Dundee wells and will be used for identification of mineral assemblages. Popko will attend a one-week Inductively Coupled Plasma Spectroscopy (ICP) workshop in April and will use ICP analyses will then be performed on samples and standards to cross-check the FTIR results.

1.2.4 FLUID SAMPLES

Hydrocarbon and produced-water samples from the Crystal Field have yet to be collected and analyzed. If possible, arrangements will be made to sample fluids from other Dundee fields as

well. Inorganic geochemical analyses of produced brines will be used in conjunction with isotope and fluid inclusion analyses of core and cuttings to determine the origin and history of the porosity-producing dolomitizing fluid.

Initial production (IP) maps show that a number of the Dundee fields have two markedly different producing regimes: a dolomite reservoir rock that comes on production at a few hundred BOPD and a vuggy dolomite reservoir rock that comes on production at 1000-2000 BOPD. Early wells in the fields, drilled in the 1930's and 1940's, were produced imprudently at very high flow rates, coned water, and watered out in a matter of months. The best locations for spotting horizontal wells to recover bypassed oil may be in between wells that coned water in these high IP areas.

The low IP dolomites may have formed by a regional process, while the high IP dolomites may represent zones of locally enhanced porosity where cross-formational fluid flow dolomitized fracture zones. If this is true, the two dolomitizing fluids could have very different chemistries, which may be reflected in the chemistry of present-day connate waters. Since fluid flow may provide the key to understanding the origin of high production-rate areas, we intend to sample formation fluids from high and low IP dolomite areas and use inorganic chemistry to interpret dolomite origin.

TASK 1.3 DATABASE MANAGEMENT

Currently, project personnel at WMU are using TerraSciences' TerraStation software to analyze and archive project data. The MTU group participating in another DOE project with the specific goal of developing and demonstrating an integrated system for database management and reservoir visualization. A Spatial Database Manager (SDBM) shell/interface and a Multi-Media Program (MMP) are currently being developed in this project using Microsoft Visual Basic 3.0.

The SDBM is a Windows shell that provides access to an underlying database engine (Microsoft Access), a well-log interpretation program (Crocker Data Processing Petrolog), mapping and cross-section software (the GeoGraphix Exploration System Workbench) and a volume visualization application (yet to be determined). The SDBM will have the added benefit of online help and tutorial information. This system, and all of its components, is available for use in the Dundee project. A. Nigrini is in charge of database management for both contracts and will coordinate software needs.

Thirty Dundee fields are being studied in this project. Well data (drillers' logs and scout tickets), log data, and production data sets for all 30 fields are now complete. The data are currently stored in the TerraSciences' database at WMU. Digitized well logs from selected wells were read into the database during the last quarter. Specific intervals are now being evaluated for S_w and other calculated parameters.

TASK 1.4 DRILLING

Drilling was delayed pending completion of an environmental site assessment. Terra Energy was reluctant to commence drilling before receiving a covenant from the Department of Natural

Resources, State of Michigan, protecting them from lawsuits for pre-existing environmental contamination. Terms of an agreement were recently agreed upon by Terra and the State of Michigan and the covenant is now awaiting signature in the Michigan State Attorney General's office. We expect that the document will soon be signed and drilling can commence in the summer of 1995. Cronus Development Corp., under contract to Terra Energy, will drill the well.

TASK 1.5 TECHNOLOGY TRANSFER

This task focuses on technology transfer of information derived in this study through academic, technical, and commercial channels. J. Allan is responsible for preparation of technical reports to DOE, for coordination of communication between project members, for coordination of technical publications and workshops, and for most other technology transfer activities.

1.5.1 MEETINGS

Meetings of the Michigan Oilfield Research Consortium (MOFRC), open to all interested parties, will be conducted by the project staff. Various aspects of the project will be discussed through poster or oral presentations. Efforts will be made to make interested parties aware of these meetings. J. Huntoon and A. Hein have put together a newsletter which will be mailed to independent oil producers and other interested parties.

The initial mailing list of potential members of the Michigan Oilfield Research Consortium is now complete. Potential members were identified either through personal contact or through their inclusion in the Michigan Oil and Gas News, 51st Annual Edition of the Michigan Petroleum Directory/Almanac. All potential members will receive the first MOFRC newsletter. Subsequent mailings will be sent primarily to interested parties. The first mailing will be completed by 5/15/95.

1.5.2 REPORTS

Multimedia Presentations on CD-ROM

D. Schueller and B. Watkins designed and developed a Multi-Media Program (MMP) shell/interface in Visual Basic 3.0 for this project and for another DOE project that the MTU staff are participating in. We intend to use this shell as a technology transfer mechanism. All data and information associated with the project will be stored on hard disk and will be accessible via the MMP. At the end of the project, all data, graphics, tutorials, manuals, etc., will be stored on CD ROM for distribution to DOE and to our target audience within the petroleum industry.

The MMP serves several purposes: (1) it archives all project reports, tables, maps, photographs, animations, etc., either within the shell itself or as files opened from other applications that can be launched from the shell (e.g., Lotus 1-2-3, Excel); (2) it provides tutorials and manuals to help less knowledgeable users access and interpret each type of information; (3) it provides user-defined pathways to, and sample data files for, some commonly used spreadsheet

applications so users can integrate their own data within the shell. Project information is available via pull-down menus in the archival mode. The MMP is operational at present. We anticipate entering results from the Michigan project into it in the next quarter.

1.5.3 PROFESSIONAL MEETINGS AND PUBLICATIONS

AAPG National Meeting

Project members ran a booth in the Exhibits Hall at the AAPG National Meeting in Houston, March 5 to 8, 1995. The booth included a poster display which described project goals and progress to date. We ran two adjacent booths, one for this project and one for our California DOE Advanced Process and Technology Program project. Wood, Huntoon, Allan, Nigrini, and Chittick operated the booth for this project. Other MTU faculty and graduate students affiliated with the California DOE project helped run the other booth. Considerable interest was generated in both projects. Several independents asked to be kept abreast of project developments and to have quarterly reports mailed to them. We gained the impression that if our horizontal well is commercially successful, we will have little trouble finding independents who are interested in drilling horizontal wells in areas that coned water and left behind bypassed oil in other Dundee fields.

1.5.4 WORKSHOPS

Tampa Workshop/Conference

On January 19 and 20, 1995 we held a meeting at the University of South Florida in Tampa to review both of our DOE projects. The Michigan project was discussed on January 19 and our California project was discussed on January 20. Each project member made a presentation on his or her work. The meeting afforded project members an opportunity to learn what everyone else was doing and to discuss project plans and accomplishments in an open forum. The meeting was very successful at accomplishing these goals.

Workshops

Workshops will be held at the MTU Subsurface Studies Laboratory (SSL) to familiarize interested parties with the computational hardware and software made available by this project and to demonstrate the reservoir characterization methodologies being developed. After training, attendees may later visit MTU to use the SSL computational facilities or may access the facility over an Ethernet network.

Later in the project, short courses and workshops will be run through professional societies (e.g., AAPG). Other, less-formal workshops may be run either in conjunction with a local geological or engineering society meeting or independently. A list of "customers" will be prepared and publicity will be generated to make these customers aware of workshops that are run independently of professional organizations.

TASK 1.6 PROJECT CONTINUATION

A Project Evaluation Report describing in detail the project status will be prepared and submitted in accordance with the Reporting Requirements.

TASK 2.3 MODELING

2.3.2 BASIN MODELING

Although the Modeling Task is not scheduled to begin until the Budget Period 2, acquisition of software has begun. At present, all of the major hardware and software purchasing decisions have been made and purchases are in progress. Purchasing decisions were made with serious attention given to cost/benefit ratios. Because the target audience for technology transfer in this project consists mainly of small independent oil exploration and production companies, price and flexibility are critically important. J. Huntoon is directing the modeling effort. During the last quarter, the following purchases were agreed upon:

1) HP650C - Color Plotter: The HP650C color plotter is a versatile, widebed continuous (roll) feed plotter that produces high-quality graphics output for display or analysis. This type of plotter is used by several small oil companies that were surveyed prior to making the purchase decision. At the current time it will be used to print postscript files, so an HP postscript card was also purchased. Software to make the printer compatible with many different types of graphics files is available. Such software was not purchased at this time. Due to the expense involved, we will attempt to use only the relatively inexpensive postscript card throughout the project, so that our methods of output generation can be easily transferred to small operators.

2) GeoGraphix - Data Management and Visualization Software: GeoGraphix Exploration System (GES) is designed to facilitate data management and visualization. It uses the same type of Geographic Information System technology that is common in more expensive types of software (e.g. ArcInfo, Intergraph), but is tailored to the needs of oil companies working with subsurface, rather than surface, data. It runs on PCs which makes it attractive to smaller, independent oil companies.

3) 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, compaction, temperature histories, lithology, heat flow, hydrocarbon maturities, and pressures, and allows for multiwell mapping of variables. It is commonly used by both small and large oil companies. We will use it in conjunction with software that has been developed in-house.

4) Akcess.basin - 2-D,3-D Basin Modeling Software: This is an extremely powerful basin modeling system that is based on work performed as part of a DOE Class I project (Enhanced Dynamic Recovery Technologies {field site located in the Eugene Island area of the Gulf of Mexico, Offshore Louisiana}) that several MTU faculty members and graduate students

participated in. The 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. Although this software may be rather expensive for small operators, we have it in our possession as a result of the DOE Class I program and decided to use it to perform regional modeling studies in the Michigan Basin. No other software offers the power and flexibility of Akcess.basin. Computational Mechanics Corporation (COMCO) has installed the software at Michigan Technological University.