DOE/BC/14983--6

QUARTERLY REPORT

MICHIGAN TECHNOLOGICAL UNIVERSITY

JULY, 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: 3rd Quarter FY 1995

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EXECUTIVE SUMMARY

The following is a chronological description of project meetings and activities for the 3rd quarter FY 1995:

- On March 30 to April 6, Allan traveled to USF to work on the project with Wood.
- On June 5, Wood presented an overview of this project to an NRC panel which was commissioned to review the DOE Fossil Energy Program.
- During the week of June 5, Allan traveled to MTU to work on the project with faculty and staff.
- During the week of June 12, Pennington and Huntoon made presentations on various aspects of MTU's DOE projects at a Society of Exploration Geophysicists (SEG) Development and Production Forum entitled: Cooperative Projects to Improve Reservoir Management. Pennington discussed the technical aspects of the project and Huntoon covered technology transfer issues.
- Following the SEG conference, Pennington spent one day each at the GeoGraphix and TerraSciences offices in Denver addressing problems with each company's software packages.
- During the week of June 26, J. Wood and W. Harrison attended the DOE Contractor Review Meeting in Oklahoma. Harrison presented an overview of this project and Wood presented an overview of another project funded by the DOE Advanced Extraction and Process Technology Program in which several members of this project team are also participating.
- In late June, A. Nigrini traveled to MTU to work on the project with MTU faculty and staff.

J. Wood returned to MTU from his leave of absence at the University of South Florida (USF) at the end of June. We are currently in the process of recruiting a part-time person to handle the formatting and loading of well-log data into our GES Workbench and other programs.

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 and wireline logs for 8526 wells, including 4785 wells that penetrate the Dundee, are now in our oil and gas well data set. Maps and cross sections have been prepared for Crystal Field and 30 other Dundee oil fields in the Michigan basin. Well-log analysis using TerraSciences TerraStation software has begun. Lithologies and water saturations are being calculated using density/porosity and Pickett crossplots. 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 8 1/2x11 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.

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). Many 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. Rock work has begun at WMU and will continue throughout the summer and fall.

Spectral analyses of on mineral standards were completed by graduate student N. Popko during the last quarter. Spectral data from standards are being 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 the McKittrick Front wells and will be used for identification of mineral assemblages. Analysis of the core samples has now begun. ICP analyses will then be performed on samples and standards to cross-check the FTIR results. Popko is doing this work as his Master's research under the direction of W. Pennington.

Currently, project personnel at WMU are using TerraSciences' TerraStation software to analyze and archive project data. The MTU group is 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.

The GeoGraphix Exploration System (GES) software package was acquired this quarter and installed on a PC in the Subsurface Laboratory at MTU. Graduate student S. Chittick is working this summer on loading logs, formation tops, and other data into the program and getting the system operational. He has already constructed 3D surface visualizations of the Dundee reservoir in Winterburn Field.

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 drilling can commence in the late summer of 1995. Cronus Development Corp., under contract to Terra Energy, will drill the well.

J. Huntoon and W. Pennington presented posters at the SEG Development and Production Forum on "Cooperative Projects to Improve Reservoir Management" in Colorado in June. Pennington discussed the Michigan Dundee Project and another MTU DOE project involving computer visualization of reservoirs in the San Joaquin Valley, California, in which Michigan Tech is also participating. Huntoon presented a poster display on Technology Transfer. The Technology Transfer talk, entitled "Facilitating interaction between universities and industry: mechanisms for personnel and technology transfer", elicited much favorable comment. Huntoon was asked to re-present it as an invited paper at the SEG Annual Meeting this fall.

J. Wood and W. Harrison attended the DOE Contractor Review Meeting in June and presented an overview of this project and of another DOE project involving computer visualization of reservoirs in the southern San Joaquin Valley of California. Harrison presented an overview of the Michigan project and Wood presented an overview of the California project. Our Multimedia CD ROM system for archiving data and distributing project results elicited favorable comment.

During this quarter, J. Allan, D. Schueller, and S. Dyl, who is the Curator of the Seaman Mineralogical Museum at MTU, submitted a proposal to the DOE Museum Science Education Program to develop an interactive computer-based Multimedia Display at the Seaman Mineral Museum to tell the story of recent changes that have profoundly affected the U. S. domestic oil industry and to show how our group in the Department of Geological Engineering and Sciences at Michigan Technological University is using funding from DOE programs (the Advanced Extraction and Process Technology Program and the Class II Oil Recovery Program) to develop affordable, high-technology solutions to some of the industry's more pressing problems. If funded, we feel that this display will be an effective technology transfer vehicle.

We are in the process of acquiring a data set on >10,000 Michigan wells from either Dwigths' or Angstrom's well log data divisions. The data set will include formation tops, lithologies, etc., in a form that can be read directly into our GeoGraphix Exploration System software. Each vendor has agreed to provide us with one county's worth of data on a trial basis. We plan to purchase the full Michigan data set from the company that provides it in a form that is most compatible with our software. During the fall quarter, J. Huntoon and her students will construct structural and isopach maps in GeoGraphix using this data and export these maps to the basin modeling software described below, where they will be used to construct thermal and fluid-flow models.

The GeoGraphix Exploration System (GES) was acquired and installed on a PC in the Subsurface Laboratory at MTU. 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. It is currently being used to visualize subsurface data in Winterburn Field.

During this quarter, BasinMod was acquired and installed on a PC in the Subsurface Laboratory at MTU. Test runs will be made using the program later this summer. Analysis of Michigan Basin data is anticipated this fall after we acquire our Michigan Basin well-data set from Dwights of Angstrom. BasinMod allows modeling of burial histories, compaction, temperature histories, lithology, heat flow, hydrocarbon maturities, and pressures, and allows for multiwell mapping of variables.

During this quarter, Access.basin was also acquired and installed on the Sun Workstation in the Subsurface Laboratory at MTU. The 3D version is now running and beta testing is currently underway. This is an extremely powerful basin modeling system that is based on work performed as part of a DOE Class I project, the Lamont Eugene Island Project: Enhanced Dynamic Recovery Technologies, 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.

A Project Evaluation Report describing in detail the project status is currently being prepared and will be submitted in accordance with the Reporting Requirements. A Topical Report summarizing data for Crystal Field is also being prepared.

SUMMARY OF TECHNICAL PROGRESS BY TASK

BUDGET PERIOD 1

TASK 1.1 PROJECT MANAGEMENT

The management tasks have gone smoothly this quarter. Various subgroups met and worked on specific tasks and subtasks throughout the quarter. J. R. Wood returned to MTU from his leave of absence at the University of South Florida (USF) at the end of June. We are currently in the process of recruiting a part-time person to handle the formatting and loading of well-log data into our GES Workbench and other programs.

Project Coordination

The following is a chronological description of project meetings and activities for the 3rd quarter FY 1995:

- On March 30 to April 6, Allan traveled to USF to work on the project with Wood.
- On June 5, Wood presented an overview of this project to an NRC panel which was commissioned to review the DOE Fossil Energy Program.
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- In late June, A. Nigrini traveled to MTU to work on the project with MTU faculty and staff.

1.1.2 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 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 and wireline logs for 8526 wells, including 4785 wells that penetrate the Dundee, are now in our oil and gas well data set (Table 1). Maps and cross sections have been prepared for Crystal Field and 30 other Dundee oil fields in the Michigan basin.

Well-log analysis using TerraSciences TerraStation software has begun. Lithologies and water saturations are being calculated (Fig. 1, 2, 3) using density/porosity and Pickett crossplots

Regional Studies

Production data has been added to the well-file database (Table 1). 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 8 1/2x11 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

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.

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.

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). Many 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. Rock work has begun at WMU and will continue throughout the summer and fall.

1.2.3 FTIR SPECTROSCOPY

Spectral analyses of on mineral standards were completed by graduate student N. Popko during the last quarter. Spectral data from standards are being 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 Crystal Field wells as well as as many of the additional fields as possible and will be used for identification of mineral assemblages. Analysis of the core samples has now begun. ICP analyses will then be performed on samples and standards to cross-check the FTIR results. Popko is doing this work as his Master's research under the direction of W. Pennington.

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.

The GeoGraphix Exploration System (GES) software package was acquired this quarter and installed on a PC in the Subsurface Laboratory at MTU. Graduate student S. Chittick is working this summer on loading logs, formation tops, and other data into the program and getting the system operational. He has already constructed 3D surface visualizations of the Dundee reservoir in Winterburn Field.

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 drilling can commence in the late 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.

During this quarter, J. Allan, D. Schueller, and S. Dyl, who is the Curator of the Seaman Mineralogical Museum at MTU, submitted a proposal to the DOE Museum Science Education Program to develop an interactive computer-based Multimedia Display at the Seaman Mineral Museum to tell the story of recent changes that have profoundly affected the U. S. domestic oil industry and to show how our group in the Department of Geological Engineering and Sciences at Michigan Technological University is using funding from DOE programs (the Advanced Extraction and Process Technology Program and the Class II Oil Recovery Program) to develop affordable, high-technology solutions to some of the industry's more pressing problems. If funded, we feel that this display will be an effective technology transfer vehicle.

1.5.1 MEETINGS

During this quarter, Harrison traveled to the University of South Florida (USF), Nigrini traveled to MTU, and Allan traveled to both USF and MTU to meet with other project members and work on specific project tasks.

1.5.2 REPORTS

Multimedia Presentations on CD-ROM

During this period, work continued on the Visual Basic programming for the Multimedia Spatial Database Manager, log files were loaded into the archive, and a CD ROM writer was acquired and is currently being installed at MTU.

1.5.3 PROFESSIONAL MEETINGS AND PUBLICATIONS

SEG Development and Production Forum

J. Huntoon and W. Pennington presented posters at the SEG Development and Production Forum on "Cooperative Projects to Improve Reservoir Management" in Colorado in June. Pennington discussed the Michigan Dundee Project and another MTU DOE project involving computer visualization of reservoirs in the San Joaquin Valley, California, in which Michigan Tech is also participating. Huntoon presented a poster display on Technology Transfer. The Technology Transfer talk, entitled "Facilitating interaction between universities and industry: mechanisms for personnel and technology transfer", elicited much favorable comment. Huntoon was asked to re-present it as an invited paper at the SEG Annual Meeting this fall. Our representatives at this meeting found it to be very successful in facilitating communication (and Technology Transfer) between various groups carrying out DOE sponsored projects.

DOE Contractor Review Meeting

J. Wood and W. Harrison attended the DOE Contractor Review Meeting in June and presented an overview of this project and of another DOE project involving computer visualization of reservoirs in the southern San Joaquin Valley of California. Harrison presented an overview of the Michigan project and Wood presented an overview of the California project. Our Multimedia CD ROM system for archiving data and distributing project results elicited favorable comment.

Ontario Petroleum Institute

W. Harrison has accepted an invitation to present a talk on this project to the Ontario Petroleum Institute in London, Ontario this September.

1.5.4 WORKSHOPS

No workshops were held during this quarter.

TASK 1.6 PROJECT CONTINUATION

A Project Evaluation Report describing in detail the project status is currently being prepared and will be submitted in accordance with the Reporting Requirements. A Topical Report summarizing data for Crystal Field is also being prepared.

TASK 2.3 MODELING

2.3.2 BASIN MODELING

Although the Modeling Task is not scheduled to begin until the Budget Period 2, acquisition and installation of software has begun. J. Huntoon is directing the modeling effort. During the last quarter, the following progress was made:

- 1) Michigan well data set: We are in the process of acquiring a data set on >10,000 Michigan wells from either Dwigths' or Angstrom's well log data divisions. The data set will include formation tops, lithologies, etc., in a form that can be read directly into our GeoGraphix Exploration System software. Each vendor has agreed to provide us with one county's worth of data on a trial basis. We plan to purchase the full Michigan data set from the company that provides it in a form that is most compatible with our software. During the fall quarter, J. Huntoon and her students will construct structural and isopach maps in GeoGraphix using this data and export these maps to the basin modeling software described below, where they will be used to construct thermal and fluid-flow models.
- 2) HP650C - Color Plotter: An HP650C color plotter was installed and is now in use. It was first used to prepare the poster displays for the SEG Development and Production Forum in June (see Subtask 1.5.3).
- 3) GeoGraphix - Data Management and Visualization Software: The GeoGraphix Exploration System (GES) was acquired this quarter and installed on a PC in the Subsurface Laboratory at MTU. 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. It is currently being used to visualize subsurface data in Winterburn Field.
- 4) 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. During this quarter, BasinMod was acquired and installed on a PC in the Subsurface Laboratory at MTU. Test runs will be made using the program later this

summer. Analysis of Michigan Basin data is anticipated this fall after we acquire our Michigan Basin well-data set from Dwights of Angstrom.

5) 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, the Lamont Eugene Island Project: Enhanced Dynamic Recovery Technologies, 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. During this quarter, Access.basin was acquired and installed on the Sun Workstation in the Subsurface Laboratory at MTU. The 3D version is now running and beta testing is currently underway.

TABLE 1

RESERVOIR CHARACTERIZATION OF SELECTED DUNDEE FIELDS IN
THE MICHIGAN BASIN
D.O.E. CLASS II - SHALLOW SHELF CARBONATES

Oil and gas well data set:

Digital data set consists of 8526 wells with latitude and longitude locations, reference datum (usually ground elevation or Kelly bushing), formations tops from the glacial drift cover to the bottom of the hole. A total of 4785 of these wells penetrate Dundee or deeper horizons. Initial reported production is recorded for each producing well. The following maps have been produced for 30 selected fields in the Michigan basin.

1. Base map with well locations, well completion type, and permit number.
2. Structural countour map on top of Dundee Formation-subsea.
3. Structural countour map on top of porosity zone-subsea.
4. Isopach map of Traverse Limestone (unit immediately overlying Dundee Fm.)
5. Initial production contour map before stimulation treatment.
6. Initial production contour map after stimulation treatment.
7. Field map showing locations of "stick" cross sections (at least 2 cross sections per field).
8. "Stick" cross sections across the field showing top of Dundee, top of porosity zone and total depth of each well in the cross section.

Well production history data set:

This is a Microsoft Excel spreadsheet with annual field production statistics and well status data. The data set includes:

1. year
2. number of producing oil wells
3. number of producing gas wells
4. new wells drilled during the year
5. wells abandoned during the year
6. total annual oil production
7. total annual gas production

TABLE 1 (CNTD)

This Excel spread sheet data has been loaded into a plotting software called PSI-PLOT to produce:

1. Production history curves (decline curves).
2. Well status history curves (producing wells, new wells drilled, wells abandoned).

Electric log data set:

This dataset currently contains 342 wells with various digitized log curves. The logs digitized include some or all of the following:

Gamma Ray	Caliper
Density	Photoelectric Factor
Neutron	Compensated Neutron Porosity
Microsperically Focused Log	Dual Lateral Log
Sonic	Dual Induction

Additionally, 194 more logs have been collected and will be added to this data set. These logs are mainly from older wells and are mostly Self-potential (SP) and Resisitvity (RES) logs.

Calculations from this digital set have produced various plots of the log data including:

1. Pickett Plot for determining water saturations.
2. Porosity/density crossplots for determining lithology.
3. Digital replotting, rescaling, and normalizing various log traces.
4. Calculations of true rock (R_t) and water resisitivities (R_w).

Field description data set:

This data set contains all available information about the general geology, production practices, production history, field development, and engineering parameters for each field.

Geologic samples data set:

All available data plus new information generated during this project for

TABLE 1 (CNTD)

mineralogic, petrographic, lithologic and isotopic properties of cores and samples from in and around each of the selected fields. Analyses include:

1. Core or sample (cuttings) descriptions.
2. Thin section analyses based on point counts.
3. X-ray diffraction analyses for mineralogy.
4. Scanning electron microscope imaging of grains, matrix and porosity. Energy dispersive X-ray determination of elemental compositions of rock materials.
5. Oxygen and carbon isotopic analyses of selected samples.
6. Quantitative porosity and permeability analyses (conventional core analyses).

Well Name: 37377 - SMITH 1-17

Figure 1 Digitized and rescaled log plot of Smith 1-17 well. GR-Gamma Ray, DENS-Lithodensity, CNL-Compensated Neutron log, MSFL- Spherically focused log (microresistivity), ILD-Deep Induction log

Figure 2 Lithology crossplot values per foot for Dundee interval in Smith 1-17. DENS-Lithodensity, CNL-Compensated Neutron log,

Well Name: **37377 - SMITH 1-17**

Depth: **3180.0** to **3350.0** by **1.00** feet

Graph

X Axis: CNL Y Axis: DENS 168 of 171 Pts plotted
Constraints: None

Figure 3 Pickett Plot for Dundee interval showing water saturation values per foot. Refer to log traces of Smith 1-17 well.

Resistivity-Porosity Crossplot

Well Name: 37377 - SMITH 1-17

Depth Interval: 3183.00 to 3350.00

Vertical Axis: Porosity % .1 100.0

Horizontal Axis: Resistivity OHM-M .1 10000.0