TITLE

USING RECENT ADVANCES IN 2D SEISMIC TECHNOLOGY AND SURFACE GEOCHEMISTRY TO ECONOMICALLY REDEVELOP A SHALLOW SHELF CARBONATE RESERVOIR: VERNON FIELD, ISABELLA COUNTY, MI.

TYPE OF REPORT: QUARTERLY

REPORTING PERIOD START DATE: MARCH 21, 2000

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ABSTRACT


The format for quarterly report format for this project will follow the outline developed for the SOW submitted to DOE as part of the original proposal. Each of the Subtasks in Task 2, and 3 is further organized to include the following topical outline suggested by G. Walker:

GOAL - SURFACE GEOCHEMISTRY SAMPLING AT VERNON FIELD

- Work Done - The principal accomplishment this period was successfully sampling part of Vernon for geochemical indicators of hydrocarbons. A North-South line approximately 3 miles long was sampled at 50 locations spaced 300 feet apart. Four types of samples were collected: surface microbial, enzyme leach, iodine and headspace gas.

- Results – The results from the surface microbial samples were promising: highs were predicted over the known extents of the old Vernon Field, while lows were predicted outside the mapped extents of the field. The enzyme leach and iodine samples arrived too late for detailed analysis in this report, but preliminary investigations suggested that these samples exhibit anomalies at the edges of the field in contrast to the apical anomaly displayed by the microbial samples.

- How Results will be Used and Why – The geochemical results will be used to guide siting the project wells and as aids to selling the prospect to partners. In general the results appear to reduce risk, but further surveys will be conducted this fall.

- Remarkable Findings/Unexpected Results – The excellent agreement of the microbial data with the known extent of Vernon Field was quite remarkable and somewhat unexpected. The iodine and enzyme leach data, if confirmed, appears to show the opposite of the microbial, e.g. highs where the microbial is low and vice versa. This was unexpected (to us) though similar reports exist in the literature.

- Potential Applications – Surface geochemistry has potential application as a “risk reducer” to Michigan Fields that are similar to Vernon Field. The technique is relatively inexpensive and can be done quickly.

- Did data support project as expected or not? – The microbial data strongly support the project and suggest that the original choice of drilling site was a good one.

- What remains to be done – Follow-up geochemical surveys will be conducted this fall to fill in the field and will extend to the Southeast, where Phase II exploratory wells have been proposed. Additional partners remain to be brought on board for the drilling phase, but we are confident that this will be accomplished in the time remaining for this phase.

- Should something else have been done? So far, things are right on track and it does not appear that anything should have been done differently. Delaying the drilling so that more geochemical work can be done first is a definite plus. (Originally, the play was to drill the first well this summer.)

- What lesson was learned? Run surface geochemistry in all phases of the project

- Future plans – Plan and execute further geochemical surveys at Vernon Field.
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Figure 2. Sample locations for 1st Geochemical Sampling

Figure 3. Plot of Microbial Survey

Figure 4. Production history chart for Vernon field from 1930 to 1982.

Table 1: Analysis of duplicate samples

Table 2. Data for Microbial Profile
EXECUTIVE SUMMARY

N/A
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Budget Period #1

Task 1 Project Management – J. Wood

Task Description – Coordinate all aspects of the project between Michigan Technological University (MTU) at Houghton, Michigan, Western Michigan University in Kalamazoo, MI and Cronus Energy in Traverse City, MI. Produce a working document that will outline the project in detail as well as set a schedule of visits and meetings. Coordinate all necessary meetings and will serve as the central repository for all project deliverables and reports.

Subtask 1.1 Technical Aspects - J. Wood

Policy – Preparation and Enforcement
The principal subtasks performed were the preparation of this document, including the master outline and coordinating a geochemical sampling party. Separate subcontracts were negotiated and submitted to Western Michigan University and Cronus Energy by Michigan Technological University.

Travel, Students and Expenditures
Travel to the sample site, Vernon Field in downstate Michigan was approved and paid for parties involved. Expenses were paid for Wood to present a paper on the project at the SPE Long Beach Meeting in June. The project presently supports 2 Ph.D. students, S. Chittick and Deyi Xie.

Subtask 1.2 Financial Reports and Accounting - A. Hein

Financial documents
All monthly, quarterly and annual statements and documents have been submitted, including the project Management Plan.

C. Asiala has organized a system for keeping copies of all expenditures, bills, invoices and related financial documents that concern this project. The university is keeping track of personnel time and pay for all parties. So far only Michigan Tech is drawing personnel salaries from this project.

Subtask 1.3 Archives - C. Asiala

Archival of Materials and reports
Electronic copies of geochemical data have been received from vendors and archived in project databases. These databases have been backed up. Printed versions will be included in reports, including this one.

Task 2 Reservoir Characterization – W. Harrison

Task Description - Collect, analyze and integrate geologic and engineering data on the Vernon reservoir, particularly structural and stratigraphic data and engineering properties. Determine the reservoir architecture as well as possible prior to drilling the test well. Acquire and interpret 2D seismic line(s). Design, execute and interpret surface geochemical survey(s). Make economic projections and help site wells for development.
Sampling program

A geochemical sampling program for the Vernon Field, Isabella Co., Michigan was prepared during the spring of 2000. On May 12, 2000, the first phase of geochemical sampling over the field was completed. The Mission Road profile (Orientation Profile) was completed and a total of 50 locations were sampled. In addition, 3 samples were collected over the proposed horizontal drill hole for Phase I (Figure 1). The Mission Road profile is a N-S profile adjacent to Mission Road across the field.

Sample collection

Soil samples were collected for microbial analysis, surface iodine, enzyme leach selective extraction, and soil head gas at selected localities. Duplicate samples were analyzed to evaluate precision error (Table 1).

Microbial Results

The microbial oil survey technique is based on the principal that hydrocarbon gases in the soil directly influence the microbial population over an oil reservoir. These gases escape from the hydrocarbon reservoir and migrate upwards in very small quantities (microseeps). Specific organisms are associated with hydrocarbon gases and there is an expected positive correlation with amount of microbes and occurrence of hydrocarbons at depth. An anomaly should remain only as long as hydrocarbons of sufficient quantity exist in the subsurface to provide microseepage of gases to the surface. Thus, this technique can be used to detect by-passed oil in depleted reservoirs.

Soil was collected 8 inches below the surface in the A-horizon for microbial analysis. Geo-Microbial Technologies Inc. did the analyses, Ochelata, OK (www.gmtgeochem.com)

The raw results for microbial are given in Table 2. Microbial data are log-normally distributed based on visual inspection and the KS statistical test. The median value is 12. The 90% quantile is a value of 30 and values above 30 are considered anomalous. A total of 6 out of 50 analyses are great than 30 with 3 of these are samples taken directly above the proposed horizontal well. Microbial data show an apical anomaly over the center of the Vernon field. Microbial is variable and generally below 25 off of the center of the field. These results suggest by-passed oil potential is good in the area of the proposed horizontal well.

Surface Iodine Results

Iodine in surface soil samples has been demonstrated in the literature as an effective pathfinder for oil and gas in the subsurface (Gallagher). High concentrations of iodine are documented elsewhere around the perimeter of subsurface oil and gas accumulations, "classic" halo anomaly, and directly above the accumulation, apical anomaly. The halo effect is interpreted as the surface expression of a reduction pipe above the oil and gas accumulation. Soil was collected from the top 1 inch of the A-horizon for surface iodine analysis. Data and interpretations for this survey will be included in the next report.

Analyses were done by Graysonte Exploration Labs Inc., Golden, CO [http://www.geotech.org/survey/ssiweb/ssiweb.html]

Enzyme Leach Selective Extraction
The enzyme leach selective extraction method is based on selective extraction of elements trapped on amorphous MnO₂ (Clark). Amorphous MnO₂ is a very effective trap for migrating cations, anions, and polar molecules. Oxidation anomalies are predicted over reduced bodies in the subsurface for a suite of elements including Cl, Br, I, As, Sb, Mo, W, Re, Se, Te, V, U, and Th (oxidation suite). Rare-earth elements often follow the same pattern as the oxidation suite. Base metals can be anomalous, but with lower contrast with the background. According to Clark, the most common form of oxidation anomalies is as a halo with a central low over the reduced body in the subsurface. These anomalies may be symmetric, asymmetric, or partial around the buried reduced bodies. Clark provides an electrochemical interpretation for halo oxidation anomalies. Apical anomalies are most often interpreted as related to faults. Since enzyme leach anomalies take 100's of years to develop, they will exist long after oil has been extracted from a reservoir.

Soil was collected from just below the top of the B-horizon for enzyme leach selective extraction analysis. Analyses were done by Actlabs-Skyline, Tuscon, AZ [www.actlabs.com].

The raw results for enzyme leach selective extraction will be included in the next report.

**Preliminary Conclusions**

There is hydrocarbon microseepage from the Dundee reservoir of the Vernon Field that is detectable by surface soil geochemical techniques based on the Mission Road profile.

Microbial data show a pronounced apical anomaly over the field and are high above the proposed horizontal well. The microbial data suggest good potential for by-passed oil. The surface iodine and oxidation suite enzyme leach results show a halo anomaly about the main part of the Vernon field with a low above the subsurface accumulation of oil in the Dundee. These results are consistent with published results from elsewhere.

**Recommendations**

The soil geochemical results from the Mission Road profile indicate that further soil geochemical sampling in the Vernon field is warranted: to confirm the anomaly pattern of the Mission Road profile and to test the hypothesis that there is an extension of the Vernon field to the east as suggested by structure contour data.

**Subtask 2.2 Reservoir Geology – S. Chittick**

**Subsurface data**

Currently all the United States Geological Survey (USGS) 7.5’ Digital Elevation Model (DEM) quadrangles for the state of Michigan have been acquired and imported into the GIS program ArcView. The SDTS DEM format files were downloaded from:


The native DEM format were acquired for a fee from:


The individual DEMs were then mosaiced together into one degree longitude by one degree latitude blocks using an ArcView extension called Spatial Tools developed by the USGS - BRD, Alaska Biological Science Center, Glacier Bay Field Station and acquired from [http://www.absc.usgs.gov/glba/gistools](http://www.absc.usgs.gov/glba/gistools). These one degree by one degree blocks were then joined to form large DEM composites of the eastern and western portions of the state (specifically Universal Transverse Mercator (UTM) Zone 16 and UTM Zone 17). The composite files were then processed to show pseudo-3D relief using a hill-shade algorithm in ArcView. Once this process was accomplished, cultural data layers and oil well locations were overlaid to indicate surface topography relating to subsurface structure.
One of the problems that has not been resolved yet is the quality of some of the DEM data sets. The horizontal striping due to poor data acquisition remains a problem. Physical land features can still be resolved on the images, but are somewhat blurred. The USGS is currently updating DEMs from 30m x 30m data spacing to 10m x 10m data spacing and over time the poor quality DEM quadrangles will be replaced by cleaner high resolution data.

One of the outcomes of joining these high-resolution data together and displaying on a large scale was the discovery of a possible meteor impact structure in the thumb area of Michigan (Figure #). The possible impact structure has a somewhat circular shaped oil field near the center of the topographic anomaly. The structure may be the result of the impact itself or draping of sediments later. Further work needs to be done to confirm that this structure is indeed an impact structure, but the initial reconnaissance looks good.

Other data compiled for this project consist of LandSat Thematic Mapper (TM) images of the entire state by county, Tiger cultural data (roads, rivers, lakes, townships, county lines, etc.) by county, Digital Raster Graphics (DRGs) (7.5' georeferenced TIF files) by county, high resolution aerial photographs by 7.5' quadrangle. These data were gathered from the Michigan DNR’s spatial data library at http://www.dnr.state.mi.us/spatialdatalibrary/ Michigan has developed a projection called the Michigan GeoRef. The Michigan GeoRef is further described here http://www.dnr.state.mi.us/spatialdatalibrary/ but was in essence developed so that one can display the entire extent of the state in one view with minimal distortion. The DRGs are being used as base maps for the geochemical survey data. Sample site locations recorded with a hand held GPS plot precisely where the should on the base maps. TM images and aerial photographs combined with the DEM data may prove invaluable in lineation determination.

Upon completion of importing all of the Michigan DEM data, the data for the surrounding states within the Michigan Basin (Wisconsin, Indiana, Illinois, and Ohio) were acquired and are now being imported and displayed within ArcView. We should soon be able to see the entire surface of the basin in psuedo-3D fashion. Future work will entail developing subsurface structure contour maps of various producing horizons and overlaying them on the current topographic work. Other work planned includes acquiring the National Uranium Resource Evaluation (NURE) aeromagnetic and radiometric data from the National Geophysical Data Center and combining these data with gravity data to form images with separate bands much like satellite imagery. This last technique is a unique approach and may be used as a future exploration tool.

Subtask 2.3 Engineering Parameters- W. Harrison

**Engineering and production data**
on field from previous wells, particularly porosity, porosity distribution, permeability, oil saturation, viscosity, API gravity, etc.
Engineering parameters are generally not directly available for the old wells in this field. It may be possible to estimate some parameters from production history data and the few wireline logs in the field.
Production history data has been compiled courtesy of Eric Taylor, Consulting Geologist from Traverse City, MI. Very high initial rates were recorded from the field, but production dropped rapidly. (See Figure 4 and attached Excel file).

**Mapping**
appropriate parameters on reservoir using geostatistics.

First quarter progress includes compiling digital database of well information for producers and dry holes in and around Vernon Field. The data is in a MS-Excel spreadsheet. Data includes permit number, well name, operator, latitude and longitude, and Michigan PLS coordinates of Qtr. Section, Section, Township, and Range. Surface
reference elevation, glacial drift thickness, Top of Traverse Limestone, Top of Dundee Ls., Top of Porosity, Initial Production (before and after Acid), and total depth of the well. Other formation tops will be added as the project progresses. All tops information was gathered from the State of Michigan Driller's reports and available scout tickets.

Only a few wireline logs exist for the Vernon Field, but some comparisons can be made with nearby wells, especially in the immediately adjacent Rosebush field to the south. Approximately 20 modern logs are available from the Rosebush field. We have acquired digital copies of most of them.

Maps of the Vernon Field are now being constructed (see Figure 1 as example. Planned maps include, Glacial Drift thickness, Top of Bedrock Structure, top of Traverse Lime Structure, Top of Dundee Structure, Top of Porosity Structure, and Bell Shale Thickness. Maps of initial and cumulative production will also be produced.

Subtask 2.4 2D Seismic- W. Quinlan

Plan for 2D seismic Survey
Lay out lines over Vernon Field reservoir. Interact with seismic contractor and oversee data collection. Assist in interpretation and provide relevant data and information to team members characterizing reservoir.

There has not been a great deal of progress in this portion of the project to this date, except for the effort to sell the project and discussing drilling operations with potential sub contractors. The following is a summary of what has been accomplished to date:

- Cronus conducted a Baseline Environmental Assessment (BEA) upon the proposed Smock 13-23 HD drilling unit, including the drill site and future production facility site. The purpose of the BEA was to delineate any existing environmental contamination upon the unit prior to conducting any operations. The BEA was then submitted to the MDEQ for adequacy determination, which upon ratification, releases Cronus and its partners from liability associated with the existing contamination. The MDEQ affirmed the BEA on April 3, 2000.

- Cronus has also secured approval from the MDEQ on the 80 acre Smock drilling unit. As the unit has an old Dundee well existing upon it (used as a brine source well for Isabella County), a spacing exception had to be petitioned to allow the 2 wells (the existing John Stough 1 and the Smock 13-23 HD) to produce. Cronus was able to get the unit ratified without the need for a time exhaustive formal hearing, and received approval from the MDEQ on April 24, 2000.

- The drilling permit application was then applied for pertaining to this unit. The permit was issued on June 14, 2000 for the State Vernon & Smock 13-23 HD1 (permit number: PN 53945).

No further activities in this subtask this report period.

Task 3 Analysis and Characterization of Producibility Problem(s) – W. Quinlan

Task Description - Analyze producibility problem(s) at Vernon Field. Use drilling and logging data obtained from new well. Design, permit and drill characterization well. Design and supervise logging program. Consult with team members regarding best location for well, log suite and data collection. Be on site during drilling and interpret MWD (Measurement While Drilling) data. Conduct flow test if
hydrocarbons are encountered. Make decisions regarding placing well on production and best practices for production.

No activities in this task this report period.

Subtask 3.1 Drilling – E. Taylor

Drilling.
Make sure driller follows instructions. Monitor MWD data and make decisions on directing the bit. Contract for and supervise mud logger.

No activities in this task this report period

Subtask 3.2 Well Logging – S. Chittick

Logging Program
Make arrangements for logging contractor. Plan logging program. Supervise logging runs.
No activities in this task this report period

Task 4 Technology Transfer – W. Harrison

Task Description - Transfer of the technology is recognized as a crucial element in this project. Special efforts will be made to deliver the results in a useable form to our target audience through:

- Meetings and personal contacts.
- Workshops and training courses on use of the data and software
- Electronic distribution of results and data on Internet
- Establishing computer links between Michigan Tech and selected companies

Special targets for this transfer are small companies and independents. The program designed to reach this audience involves two key steps: (1) development of case histories and examples that have immediate interest to them, and (2) take these case histories and examples along on the road and demo them at local meetings and in individual offices, face-to-face. This will be a high priority.

Subtask 4.1 PTTC Workshops – W. Harrison

Workshops
A mini-workshop was held in Traverse City at the May monthly Michigan Oil and Gas Association meeting. This 2-hour workshop provided Michigan operators and State regulators with update information about the progress of this project as well as, a second DOE funded Project studying the Role of Fractures in Michigan Reservoirs. Jim Wood, Steve Chittick, and William Harrison made presentations at this workshop. There were 26 attendees.

Harrison made a presentation on the reservoir characterization and preliminary geochemical results at the Annual DOE Contractor's Meeting in Denver in late June. Wood made a similar presentation at the Long Beach SPE meeting in June.

Case histories
None
Tutorials.

None

Subtask 4.2 Reports – J. Wood

Publications
Publish project results in DOE reports and in scholarly journals.

Presentations
Wood, J. R., 2000 – June SPE Meeting in Long Beach, CA. Presentation of project to date, including surface geochemistry results

Harrison, W. B., 2000 – June DOE Contractors Meeting in Long Beach, CA. Presentation of project to date, including surface geochemistry results

Present results at local and national meeting of geological societies, such as the AAPG.

Subtask 4.3

Newsletter
Publish project results, updates and news in hardcopy and electronic newsletters published by The Subsurface Visualization Lab at Michigan Tech. Place relevant results on Internet in timely fashion.

Task 5 Continuation – J. Wood

Task Description - Prepare reports and documentation for Budget Period #1. Evaluate progress on project and make a decision on whether to ask for funding to continue onto Budget Period #2.

No activities in this task this report period.

Subtask 5.1 Topical Reports – Staff

Topical Reports as specified in Attachment C, pp. B-C-7 to B-C-16.
Experience in previous Class Projects indicates that the best approach here is to distribute the text of the requirements along with the relevant tables and have the appropriate project personnel work on them and fill in the tables as the project progresses.

Subtask 5.2 Project Review - Staff

Project Review
Meet with project staff and DOE Project Manager(s) to present results of project through 1st budget period and decide whether to proceed to Budget Period 2.

Subtask 5.3 Renewal Request

Renewal request
Revise budget as necessary and update tasks as appropriate.
Table 1: Analysis of duplicate samples

At a few localities outside of and within the Vernon Dundee Field boundaries duplicate samples were collected. These samples were sent out to analytical laboratories under a separate number that could not be connected with the regular sample number. These samples were analyzed as an indication of precision error and are compared for the various techniques below.

**Microbial**

Soil sample 8 inches below surface in A-horizon
Analyzed by Geo-Microbial Technologies Inc., Ochelata, OK

Raw Microbial in Duplicate Samples

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Conclusion: Based on the 4 duplicate analyses the precision error is about 10 for raw microbial

**Iodine**

Soil sample from top one inch of the surface
Analyzed by Graystone Exploration Labs Inc., Golden, CO

Location 2000-05-12-002
Location 2000-05-12-024
Location 2000-05-12-046
Location 2000-05-12-049

Conclusion: Based on the 4 duplicate analyses the precision error is about 0.1 ppb for raw surface iodine

**Enzyme Leach Selective Extraction**

Soil sample from top of the B-horizon. Analyzed by Actlabs-Skyline, Tuscon, AZ.
Only one duplicate sample was analyzed for multiple elements.
Location 2000-05-12-24 (all in ppb, negative value=analyte not found at that detection limit value)

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Michigan Technological University

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Table 2. Data for Microbial Profile

Table 2 is missing. It will be inserted on the next quarterly report.
Figure 1. Location Map for Vernon Field
Figure 2. Sample locations for 1st Geochemical Sampling
Figure 3. Plot of Microbial Survey
Figure 4. Production history chart for Vernon field from 1930 to 1982.