TITLE

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

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ABSTRACT

(Note: This abstract summarizes current project activity in bullet format that includes the suggested headings, It will be rewritten and reformatted for the final report.)

GOAL -DRILLING AND SURFACE GEOCHEMISTRY SAMPLING AT VERNON FIELD

- Work Done - In this reporting period, the principal accomplishment was the drilling lateral offshoots for the State Vernon & Smock 13-23 HD1 (permit number: PN 53945) well at the proposed location Vernon Township, Isabella County, Michigan. The surface geochemical sampling program continued, more than doubling in size and initial attempts were made to develop techniques to sample and analyze soil gases based on SPME (Solid Phase Micro Extraction) technology.

- Results – The Smock well was successfully drilled to target depth during the period October 15 to November 3. Two laterals were required to locate a pay zone approximately 175 in length. However difficult reservoir conditions precluded putting the well in production pending further analysis and work. The geochemical survey was extended to the area East of the Smock and showed an exaggerated high to the Northeast. It also shows a significant high over the area proposed for a 2nd demonstration well. These results will be on the agenda for further discussion at the annual meeting scheduled this March in Tampa, Fl.

- How Results will be Used and Why – The demonstration well will be placed on production as soon as possible and the reserves calculated. An extensive postmortem of the well, including the geology and geochemistry used to site the well as well as the engineering required to bring it on production (if that proves the case), will be conducted and the results presented at the meetings of the Michigan Basin Geological Society and elsewhere. The new geochemical results will be used to guide siting future (2nd Phase) project wells and as aids to selling the prospect to partners. Plans for still further surveys will be also be on the agenda for the spring advisory meeting.

- Remarkable Findings/Unexpected Results – A number of unexpected geological results were uncovered by the Smock well, including the confirmation that the top of the Dundee Formation is exceeding irregular at the Bell Shale contact. While the microbial geochemical surveys continued to define the extent of Vernon Field, the new large anomaly to the Northeast, termed the Isabella Road anomaly continued to grow as the sampling program expanded. Analysis of the iodine and enzyme leach data continued and the enzyme leach data continued to show promise as a useful tool. Further work is in progress on these samples, and we are now attempting to use SPME technology on the samples to see if hydrocarbon gases can be detected. This method would compliment the direct measurement of

soil gas mentioned above in that it would be detecting the paleo gas signature if successful. That is because the enzyme leach would release material frozen into the solid diagenetic phases as the field developed.

- Potential Applications – The results from the drilling of the Smock well will be of considerable interest to the local Michigan Gas and Oil Industry. In particular, the findings on the contact irregularities between the Dundee and Bell Formations will be of interest. The drilling strategy, which included using multiple laterals to probe for bypassed oil, may also prove to be a valuable lesson in locating reserves in these types of formations. If the SPME surface geochemistry proves viable, it has potential application as a more effective and economic "risk reducer" in Michigan Fields similar to Vernon Field as well as elsewhere. The technique is relatively inexpensive and can be done quickly.

- Did data support project as expected or not? – The Smock well supported the project in that it provided new data and approaches to locating reserves. However the total contribution of this well toward recovering missed opportunities remains to be fully accessed. It is anticipated that this will be a primary topic of discussion in the annual postmortem review this winter. The surface geochemistry data continue to strongly support the project. Now that the Smock well has been drilled, the geochemical data can be reinterpreted in light of those results. Surface geochemistry continues to emerge in this project as a more valuable and flexible tool than originally expected. In fact, the development of surface geochemistry techniques and studies may emerge as the primary benefit of the project.

- What remains to be done – A second follow-up well needs to be sited and drilled. Lessons learned from the first well need to be digested and put to work in implementing the second demonstration well. In particular, we need to look carefully at reducing the risk of encountering economic pay zones. While the surface geochemistry seems to have potential for locating hydrocarbon anomalies, we still need to develop ways to access the potential for successful development of an anomaly. One possibility is to investigate the possibility of small diameter (slimhole) "dipstick" well to locate and measure the hydrocarbon reservoir directly before siting and drilling the lateral wells. More geochemical surveys need to be conducted this spring at Vernon field and elsewhere, building on the knowledge and expertise gained from the first year studies. Laboratory techniques need to be developed to collect and analyze gases collected directly from the soil horizon.

- Should something else have been done? Increasingly it appears that we should have done something to improve the chances for an economic success by drilling inexpensive "dipstick" wells. The pros and cons in this would be a good topic for discussion at the annual postmortem meeting.

- What lesson was learned? The demonstration well has produced a number of lessons on the geology and engineering practices of the Upper Dundee. One of the

primary tasks at the annual review will be to evaluate and document these lessons. Two items seem paramount: one, plan multilateral wells from the beginning to probe laterally for oil pockets, and two, pay attention to the potential for plugging of the reservoir with the drilling fluids. Additionally, it appears that surface geochemistry surveys should be run in all phases of the project.

- Future plans – Plan for Project Continuation application at the Annual Meeting by detailed postmortem of the Smock demonstration well and the feasibility and advisability of continuing with the second proposed well to the Southeast of the Smock well. Plan and execute further geochemical surveys at Vernon Field and elsewhere. Discuss the plans for the seismic portion of the project. Advise the study group on the progress with the 3D seismic data set over Stoney Point Field (Michigan) and see if we should transfer time and effort to that data set instead of acquiring new seismic data. Develop a technique to sample and analyze C1 – C8 soil gases.

DISCLAIMER

LIST OF GRAPHICAL MATERIALS

EXECUTIVE SUMMARY

The geochemical sampling team collected additional 148 samples at Vernon Field along 5 new traverses. Most of the locations were sampled for three types of analyses: microbial, iodine and enzyme leach; no results from the second batch of samples were available in time for this report.

In addition to the sampling, a study was begun on the feasibility of collecting and analyzing hydrocarbon gases (C1 – C8) directly. Although several companies offer these services, the cost ($200-300/sample w/o sampling fee) is high, on par with the cost of a 3D seismic survey, and may not include the raw data. However direct sampling of reservoir gases collecting in the soil appear to offer the best approach and should be included in this study. It would probably work well at Vernon Field. It may be possible to lower costs considerably; initial estimates of $20/sample for GCMS (Gas Chromatography – mass spectrometry) analysis are attractive and might induce to Michigan producers to include soil surveys in their routine field work-ups.

A complete set of digital data was assembled for Vernon Field and nearby locations. The set consists of well locations, formation top picks, lithologies and scanned images of driller's reports and scout tickets. Well logs are still being located.

The annual meeting for the Class Revisit work group is tentatively scheduled for the week of March 1-7 in Tampa, Fl. By that time all of the geochemical data will be available and final decisions regarding drilling can be made.

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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 Exploration Company LLC 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 Exploration Company LLC 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.

The Atlas program has been altered to plot the GeoChem Sample locations in bubble plots according to the type of chemical concentration chosen by the user. The GeoChem data can be plotted simultaneously with the well locations or it can be plotted separately. The GeoChem data can also be edited from within the Atlas program. The GeoChem data is stored in 2 tables separate from the well data tables. The first table holds the Permit (unique number assigned to the sample) and its latitude/longitude coordinates. The second table holds the Permit, type of concentration, and concentration value. This allows multiple GeoChem concentration values for each sample.

The Subsurface Visualization Lab Web Site (http://www.geo.mtu.edu/svl) has been updated with reports and figures that pertain to the project. Ongoing updates will be added throughout the project.

Additional records in the Atlas Database of the Michigan Basin are being updated with the proper Oil Field names (previously, an undefined field for most of the Michigan wells in the DNR database).

The Atlas Database contains formation depths from several sources. An analysis program is being run to determine the extent of the differences in depths chosen by each source. Depths within one foot will be considered accurate, but further study will be made on formations that show differences in depth greater than one foot to determine which depth is the most correct interpretation of the formation at that well location.

Processing of DEM and SDTS files

A Visual Basic program has been developed to convert the 1-degree DEM files to Bitmap images. The DEM Header information is displayed on a form, the Elevation data is read into an array, and then the array is converted to the 24-bit bitmap format using a case structure to convert the elevation values to colors. The image is displayed in the program and can be saved to disk in the BMP format. Procedures have been written to write DEM Headers of multiple DEM files to a database and also to tile 4 DEM files together. These procedures will be combined so users can select multiple DEM files and tile them together.

A separate Visual Basic program has been developed to convert the SDTS files to Bitmap images also. The LEADTOOLS control is used to display the image and save it to a BMP file.

Automating the Generation of Oil Field Posters
Oil Field Data, exported from the Atlas program, is being processed by a Visual Basic program to automatically generate poster presentations of the 2D and 3D Dundee and Top of Dundee Porosity surfaces in the Golden Software Surfer 7.0 environment.

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.

Subtask 2.1 Surface Geochemistry – T. Bornhorst

Preliminary Report on Surface Geochemical Results along the Mission Road profile over the Vernon Field

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% quintile 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 Graystone 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 MnO_2 (Clark). Amorphous MnO_2 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:

http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/7_min_dem/states/MI.html.

The native DEM format were acquired for a fee from:

http://edcwww.cr.usgs.gov/Webglis/glisbin/search.pl?7_MIN_DEM.

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. 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 photgraphs 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**).
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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

Location 2000-05-12-002	10 versus 8 average 9 difference from average +/- 1
Location 2000-05-12-024	26 versus 15 average 20.5 difference from average +/- 5.5
Location 2000-05-12-046	1 versus 29 average 15 difference from average +/- 14
Location 2000-05-12-049	35 versus 15 average 25 difference from average +/- 10

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	2.2 ppb versus 2.3 ppb average 2.25 difference from average +/- 0.05
Location 2000-05-12-024	2.4 ppb versus 2.1 ppb average 2.25 difference from average +/- 0.15
Location 2000-05-12-046	1.9 ppb versus 2.1 ppb average 2.0 difference from average +/- 0.1
Location 2000-05-12-049	1.5 ppb versus 1.5 ppb average 1.5 difference from average +/- 0

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

Sample Id	S.Q.Li	S.Q.Be	S.Q.Cl	S.Q.Sc	S.Q.Ti	V	Mn	Co	Ni	Cu	Zn	Ga	Ge
2000-05-12-024E	-2	-2	7882	-100	113	101	296	11	6	31	14	-1	-0.5
2000-05-12-101E	2	-2	7066	-100	-100	112	388	8	6	23	11	2	-0.5

As	Se	Br	Rb	Sr	Y	Zr	Nb	Mo	Ru	Pd	Ag	Cd	In	Sn	Sb	Te
14	6	258	6	185	17.4	12	-1	9	-1	-1	-0.2	-0.2	-0.1	-0.8	1.5	-1
15	7	186	6	164	21.4	7	-1	10	-1	-1	-0.2	-0.2	-0.1	-0.8	1.2	-1

I	Cs	Ba	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
98	-0.1	93	12.4	11.5	4.9	22.5	4.5	0.9	3.4	0.6	2.6	0.5	1.6	0.2	1.2	0.2
72	-0.1	108	11.8	9.1	5.6	27	6.1	1.3	4.6	0.7	3.3	0.7	2	0.3	1.5	0.2

Hf	Ta	W	Re	Os	Pt	Au	S.Q.Hg	Tl	Pb	Bi	Th	U
0.4	-0.1	-1	-0.01	-1	-1	-0.05	-1	-0.1	1	-0.5	0.9	0.6
0.2	-0.1	-1	-0.01	-1	-1	-0.05	-1	-0.1	-1	-0.5	0.6	0.5

VERNON FIELD GEOCHEM SAMPLE SITES				ANAYTICAL RESULTS		
yyyymmddnnn		UTM				
FullNumber	Sample No.	EW UTM	NS UTM	Microbial	Iodine - G	Iodine - E
20000512001	1	679789	4844886	24	3	196
20000512002	2	679783	4845002	10	2	182
20000512003	3	679780	4845105	4	3	181
20000512004	4	679773	4845206	6	3	
20000512005	5	679779	4845302	20	3	34
20000512006	6	679783	4845405	7	2	
20000512007	7	679775	4845503	16	2	74
20000512008	8	679774	4845601	10	2	
20000512009	9	679773	4845706	8	2	
20000512010	10	679769	4845802	1		100
20000512011	11	679768	4845910	14	2	
20000512012	12	679770	4846005	12	2	
20000512013	13	679761	4846105	6	4	49
20000512014	14	679760	4846219	12	2	
20000512015	15	679756	4846309	15	3	286
20000512016	16	679751	4846408	5	2	
20000512017	17	679743	4846514	24	3	120
20000512018	18	679724	4846444	12	3	
20000512019	19	679741	4846713	4	3	254
20000512020	20	679734	4846812	18	2	
20000512021	21	679728	4846903	22	3	238
20000512022	22	679727	4847006	23	3	
20000512023	23	679725	4847108	3	3	98
20000512024	24	679721	4847207	26	2	98
20000512025	25	679690	4847292	8	3	105
20000512026	26	679688	4847410	31	2	
20000512027	27	679692	4847502	10	2	43
20000512028	28	679682	4847622	80	2	
20000512029	29	679696	4847710	35	2	
20000512030	30	679699	4847748	18	2	
20000512031	31	679692	4847904	37	2	51
20000512032	32	679682	4847996	18	2	
20000512033	33	679682	4848106	11	2	169
20000512034	34	679680	4848205	5	2	
20000512035	35	679678	4848312	26	2	
20000512036	36	679665	4848405	11	2	122
20000512037	37	679668	4848505	2	3	
20000512038	38	679644	4848601	42	3	133
20000512039	39	679648	4848824	6	3	
20000512040	40	679630	4848905	6	2	56
20000512041	41	679651	4849005	8	5	
20000512042	42	679652	4849104	5	2	
20000512043	43	679644	4849198	19	2	
20000512044	44	679619	4849305	23	2	
20000512045	45	679639	4849451	7	2	95
20000512046	46	679642	4849510	1	2	78
20000512047	47	679635	4849610	13	2	158
20000512048	48	679944	4847453	36	2	
20000512049	49	680047	4847454	35	2	
20000512050	50	680122	4847455	61	2	

Table 2. Data for 1st Geochem Profile

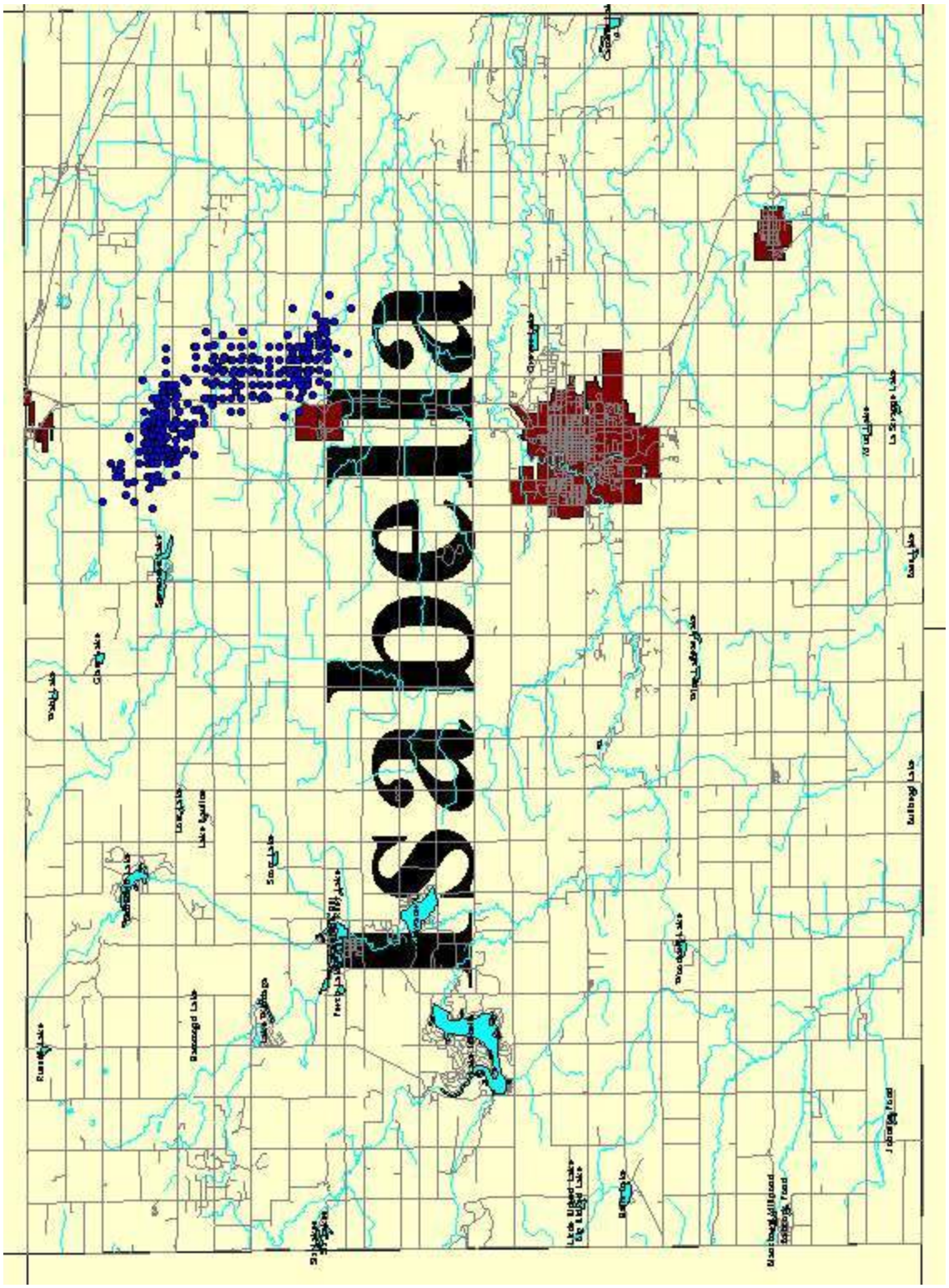

Figure 1. Location Map for Vernon Field

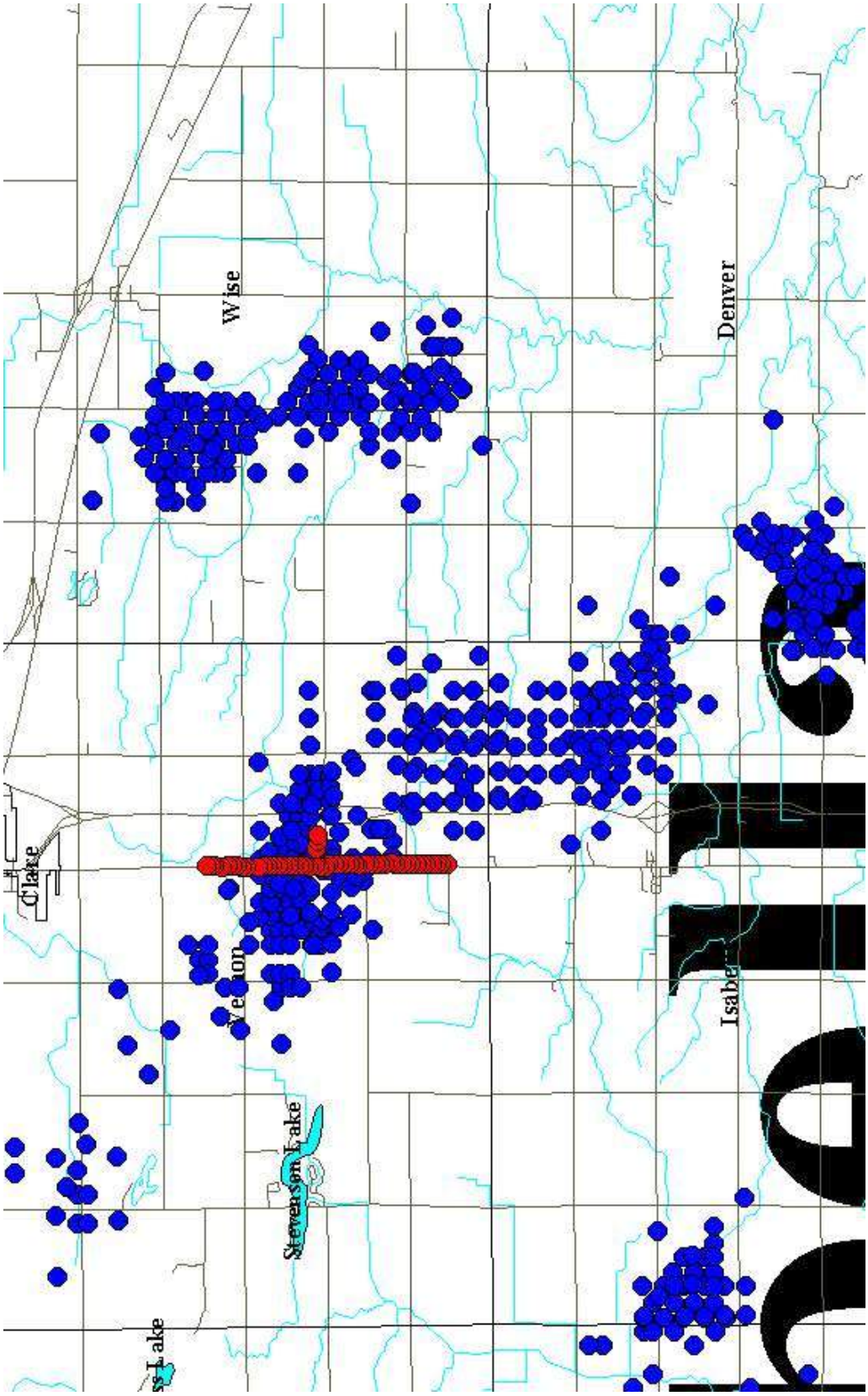

Figure 2. Sample Locations for 1st Geochemical Sampling Trip

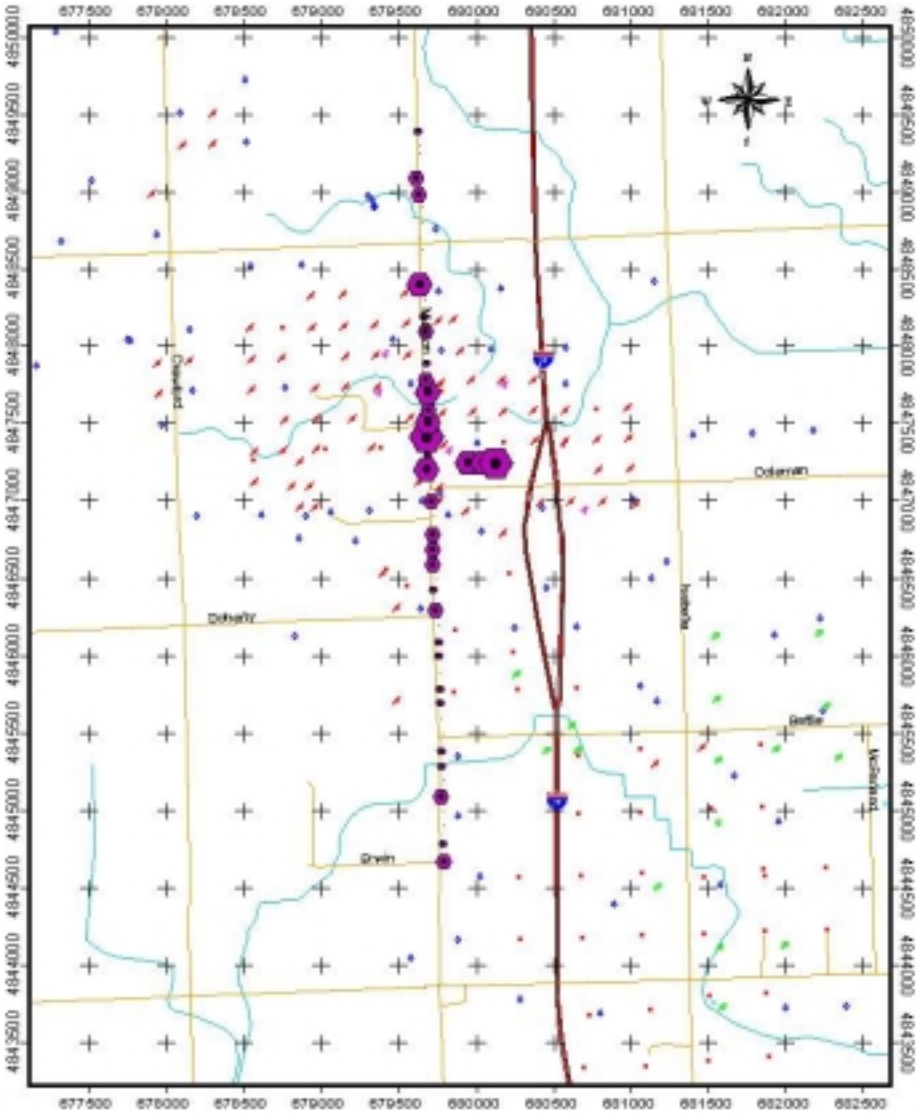

Figure 3. Plot of Microbial Survey

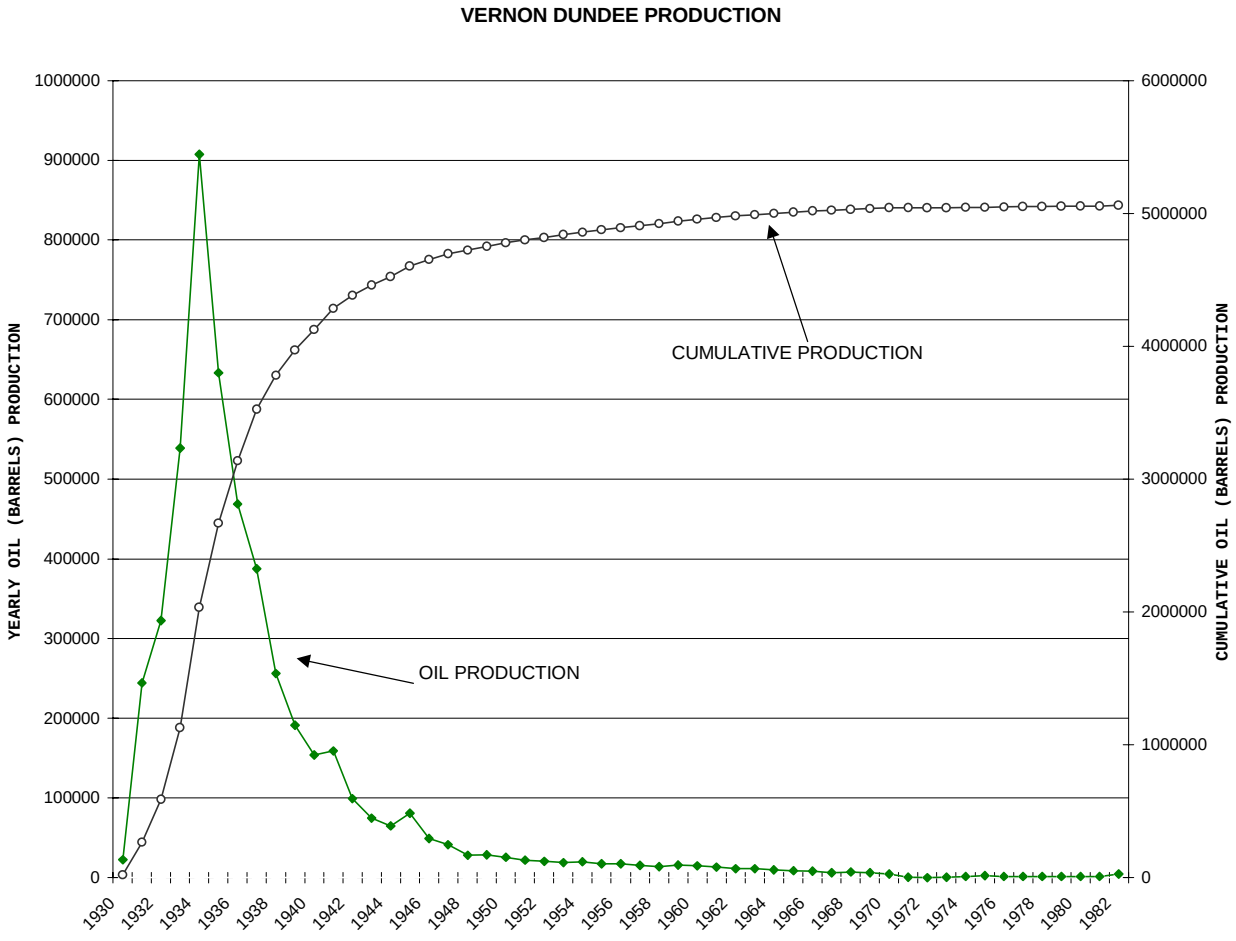

Figure 4. Production history chart for Vernon field from 1930 to 1982.

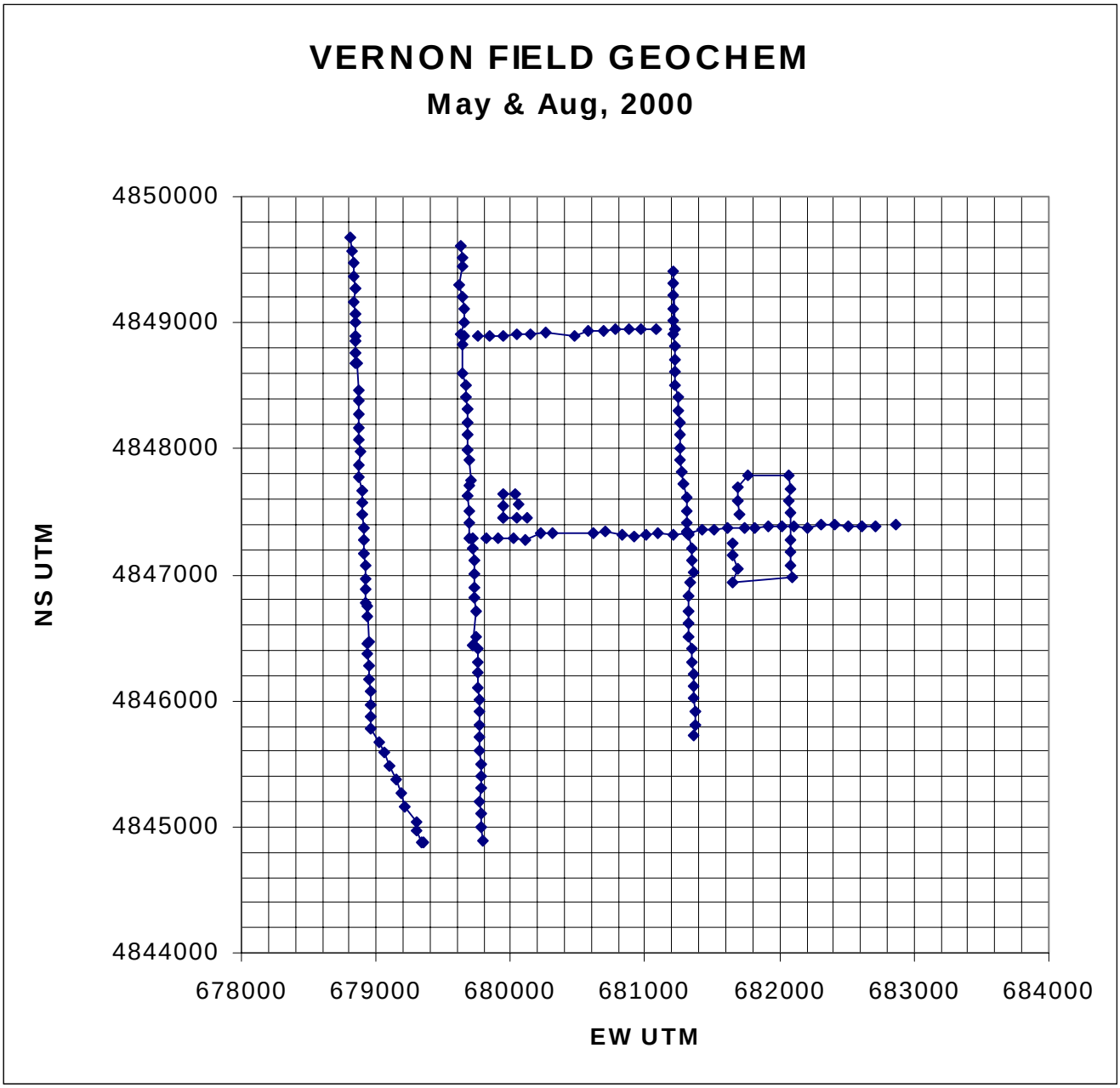

Figure 5 Sample Locations for 1st and 2nd Geochemical Sampling Trips.

APPENDIX I. ABSTRACTS FROM PREVIOUS REPORTS

Report #2: October 2000

ABSTRACT

(Note: This abstract summarizes current project activity in bullet format that includes the suggested headings, It will be rewritten and reformatted for the final report)

GOAL -SURFACE GEOCHEMISTRY SAMPLING AT VERNON FIELD

Work Done - In the first reporting period, the principal accomplishment was successfully sampling part of Vernon for geochemical indicators of hydrocarbons. At that time, a North-South line approximately 3 miles long was sampled at 50 locations spaced 300 feet apart and four types of samples were collected: surface microbial, enzyme leach, iodine and headspace gas. In this (2^{nd}) reporting period, the initial line survey was extended to include 148 more samples arrayed acrossfive5 1-2 mile lines. Samples were collected for 3 types of analysis, microbial, iodine and enzyme leach. (Headspace gas was dropped.)

Results – The results from the first 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 that arrived too late for detailed analysis in the first quarterly report arrived and seem to confirm the microbial results. However as noted last time, these samples exhibit anomalies at the edges of the field in contrast to the apical anomaly displayed by the microbial samples. More than one line is needed to use these types of anomalies. When the second series of sample results arrive we will be in a better position to assess the iodine and enzyme leach techniques.

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 Filed 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.

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. Subsequent analysis of the phases 1 iodine and enzyme leach data also support the initial choice of drilling targets, although they appear to exhibit edge rather than apical anomalies.

What remains to be done – A second follow-up geochemical surveys was conducted this fall at Vernon field and was extended to the Southeast, where Phase II exploratory wells have been proposed. Techniques should be developed to collect and analyze gases collected directly form the soil horizon.

Additional partners still 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. Also, expect the first several sampling trips to be learning experiences. For example, we now know that it is important to send off the microbial samples promptly. Also, errors regarding the sampling depth occurred and needed correction. This was due to only having several members of the team actually take samples the first time. Everyone needs to be brought up to speed on all aspects of the sampling. In particular, sampling needs to be carefully thought out and executed. Too much time and money can be wasted if samples are taken incorrectly.

Future plans – Plan and execute further geochemical surveys at Vernon Field. Develop a technique to sample and analyze C1 – C8 soil gases.

APPENDIX II. Report on the State Vernon & Smock 13-23 HD1

Introduction

As part of the Class Revisit Program, a university-industry- DOE consortium drilled a successful multi-lateral well in Vernon Field, Isabella County, Michigan. The State Vernon & Smock #13-23 was spudded October 16, 2000 in the Vernon Field and drilled to a total depth of 4630 feet, bottoming in the (M. Devonian) Dundee Formation. The first lateral encountered shale in the expected pay zone and was abandoned after drilling 750+ feet. The second lateral was drilled 9 feet deeper to the NE and located 125 (lateral) feet of pay in the Dundee Formation on November 4. Drilling was preceded by a surface geochemistry survey that confirmed an anomaly in the area.

The purpose of this project was to develop and demonstrate new techniques for locating and producing bypassed oil in the Shallow Shelf Carbonates. A previous demonstration well, the TOW 1-3 HD, drilled in Crystal Field (DOE Class program) had shown that horizontal wells could be used to locate and produce bypassed oil. The TOW #1 HD, has produced 100,000 bbls of oil since 1993 and is projected to produce an additional 50,000 – 100,000 bbls before the end of its productive life. A post mortem study concluded that this well was successful because it skimmed the top of the reservoir just below the (Bell Shale, U. Dev.) seal in a structural high. However, subsequent horizontal wells, both at Crystal Field and elsewhere, produced mixed results, and operators are not as enthusiastic with the prospects as they were initially. This project sought to rekindle interest in the use of horizontal drain wells by: (1) using a multi-lateral well to probe for hydrocarbons, and (2) using surface geochemistry to pinpoint favorable areas prior to drilling.

History of Vernon Field

Vernon Field is located in T16N-R4W in Vernon Township, Isabella County MI (Figure 1). The field was developed in the 1930's and redeveloped once in the 1950s. It was generally developed on 10-acre spacing (Figure 1) with several secondary disposal wells. The field produced 5 million barrels of oil from the original 78 wells with an average recovery of 5,700 bbls/acre. The main producing zone is the upper Dundee ("Rogers City") which is a shallow-shelf carbonate, locally altered to porous, vugular dolomite by hydrothermal fluids. The field is situated on a plunging anticline, but the oil pool is primarily the result of an updip permeability barrier-type stratigraphic trap, sealed to the south by impervious limestone. The top seal is the Bell Shale. Reservoir pressure is maintained by a strong bottom-water drive and the original oil-water contact is projected at a subsea depth of –2950 feet. The maximum gross pay thickness was 55 feet.

The Geochemical Survey

Prior to drilling, a surface geochemical survey was run over the area (Figure 2) using several different geochemical techniques and a good anomaly was detected using microbial indicators. The surveys were conducted in several stages in May and August of 2000 and later in November as the well was being drilled. The survey locations are shown in Figure 2. The May survey was a line profile across Vernon Field parallel to Mission Road and was designed to test several geochemical methods. These included: surface iodine, enzyme leach on samples from the "B" soil horizon, head space gases from sample depths of about 36 inches and microbial survey. Full descriptions and results from these surveys will be reported elsewhere. The results indicated that the microbial survey produced the best results and was adopted for all subsequent surveys.

The May survey detected a positive microbial anomaly over the site of the proposed well, which was confirmed by both subsequent surveys.

The Demonstration Well: State Vernon & Smock #13-23

The demonstration well was sited to pass on an East-West line between a gap in the 10-acre pattern (Figure 1) based on subsurface geology and historical production from previous wells. The first lateral drilled as expected until the bit exited the curve and failed to penetrate either limestone or dolomite. Drilling continued for 751 feet until it was determined that the shale was too extensive and the bit was pulled back, repositioned to penetrate 9 feet deeper and to the SE of the first lateral. The second lateral penetrated carbonates as expected, including approximately 110 feet of good dolomitic reservoir.

Work is currently on going at the well to successfully isolate and produce the reservoir section of the second lateral. During initial testing, it has become evident that natural fracturing within the reservoir is contributing water production while bypassing recoverable oil reserves. In addition, it has been learned that extensive formation damage while drilling has resulted in a plugging of the pay section within the lateral. As such, plans to run 4.5" casing through the second lateral are now being contemplated, to effectively isolate the pay sections and effectively treat and produce them.

Summary - Lessons Learned

The State#1-Smock well has provided us with several lessons, the most important being that in drilling old fields like Vernon it pays to begin with a drilling program that includes a horizontal well with multi-laterals. In this case, the first lateral drilled encountered a shale plug that was avoided with the second lateral. A vertical well or a single-lateral horizontal well would not have been successful.

It has also been learned that natural fractures may have a key role in the production of these carbonate reservoirs. Isolating productive regions from water conductive fractures may be an important issue in recovering significant reserves. In addition, formation damage due to pulverized cuttings and drill pipe abrasion appears to be prevalent issue within porous zones, even after relatively short periods of lateral drilling exposure.

An additional lesson is that geochemical surveys, particularly microbial, are worthwhile in these fields. They are relatively inexpensive and in this case appeared to provide reliable guides to the presence or absence of hydrocarbons.

Finally, our knowledge of the state of the upper Dundee Formation greatly increased as a result of this exercise. We now feel that the top of the Dundee near the Vernon Field represents an exposed karst surface spotted with deep sinkholes filled with shale, perhaps similar to modern day topography around Tampa Fl.