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

In this reporting period two main accomplishments stand out. The Springdale task is in play in the northern Michigan Basin and the geochemical survey work over the Springdale prospect continued to progress. We still need to characterize the play in terms of the type of trap (basal reef diagenetic (?)) and its relation to the well documented pinnacle reef play.

Also, we have become aware that Capac Field in the southern reef trend (Figure 1) is a possible analog to Springdale and so will be looking more closely at the literature on that field, particularly the work by Bowers (1987).

Future work is directed toward further defining the Springdale project via more wells and examination and characterization of well cuttings. One to two more geochemical surveys are planned, one this spring and a final one in early fall.

Based on current oil prices and Springdale production as of January 2005, an ROI, (defined as Total liquids revenue, \$5.45m/ DOE support, \$1.45m) better than 3.75. This does not include gas revenues, which have not yet been calculated.

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Figure 6. Conceptual model for new inter-reef play based upon the Springdale demonstration site. A reservoir model for this play is being developed based upon analysis of cuttings of carbonate rocks from horizontal wells and surface geochemistry along horizontal well paths. Black line is horizontal lateral shown penetrating inter-reef dolomite reservoirs. Note similarity to Capac Field (Figure 8).

Figure 7. Normalized chromatogram of soil gas hydrocarbons from one sample along the trace of a horizontal well in the Springdale demonstration area. Geochemical analysis is used to aid in the planning of the location of horizontal well paths and horizontal lateral length.

Figure 8. North to South cross-section through the mid-Silurian units of the Capac field, northern St. Clair County, Michigan, showing general lithologic associations. Blacked-out sections of wells indicate some of the cored intervals studied (Bowers, 1987).

Figure 9. Mid-Silurian subsurface stratigraphy and nomenclature of the southern and central Michigan Basin (Bowers, 1987).

1.0 EXECUTIVE SUMMARY

New Findings

In this reporting period two main accomplishments stand out. One, the Springdale task is maturing into a significant new play in the northern Michigan Basin (Figure 1) with monthly production levels from the basal Niagaran Reef (Figure 2) horizontal wells approaching 10,000 barrels per month (Figure 3). The cumulative liquids production for the entire play since its inception (February, 2004) is now over 118,000 barrels with production from six existing wells still increasing (Figure 4). New wells are still coming on line with more in the planning stages. (Associated gas production at Springdale is significant and will be reported later.)

The second accomplishment is the maturing of the geochemical survey work over the Springdale prospect site (Figure 5). The strategy developed over the past year has evolved from grid sampling to direct sampling over proposed horizontal well trajectories. This has cut costs, which had been rising dramatically, and focused attention on intervals of interest as defined by 2-D seismic surveys and geologic mapping. We still need to characterize the play in terms of the type of trap (basal reef diagenetic (?)) and its relation to the well documented pinnacle reef play.

Also, we have become aware that Capac Field in the southern reef trend (Figure 1) is a possible analog to Springdale and so will be looking more closely at the literature on that field, particularly the work by Bowers (1987).

Lessons Learned

The main lesson of Springdale continues to be that new production all comes from a thin zone in the Brown Niagaran (4-20 feet (?)) that could not have been located or produced with vertical wells. Also, the productive intervals appear to be dolomitized limestone either separated from or encased in impermeable limestone, with very abrupt transitions.

Should Something Else Have Been Done?

We are still working to show that surface geochemistry can be used to locate the transition from tight limestone to pay by sampling along the trajectory of the horizontal well onto the ground surface.

Goals and Results

Our final project goal will be to determine the type of trap involved at Springdale, if possible, and relate that to the surface geochemical signal.

Applications

During this reporting period (Jan - Mar) one new well, the Kovach 15-16 HD was brought on line, using the techniques developed during the course of this project. This well brings to six the total number of Springdale wells now producing.

Did Data Support Project or Not?

To date approximately \$1.45 million DOE dollars have been invested in this project through March 30, 2005 and the Springdale play alone has paid out over \$5.45 million (based on \$46/bbl oil and 118,000 barrels total liquids production to January 1, 2005). Using these figures, a “DOE ROI”, defined as Total liquids revenue (\$5.45m)/DOE support (\$1.45m) better than 3.75 can be calculated. (Note this does not include gas revenues, which have not yet been calculated.) Industry and university cost share comes to approximately \$2.9 million through April 30, 2005.

Future Work

Future projections are difficult at this time since much depends on how successfully the play can be exported out of the immediate Springdale area to the rest of the reef trend. The pinnacle reef play produced over 800 MMbbl of oil from 1970 to present. We note that the original pinnacle reef play produced over 800 MMbbls of oil and is still a major source of hydrocarbons in Michigan. There appears to be significant upside potential for this play.

In the time remaining for this project, it is due to close September 30 2005, we plan to drill 1-2 more wells and run more surface geochemistry profiles. We hope to be able to show a convincing link between the surface geochemical anomalies and the proven production at Springdale and so will concentrate on resampling some of the original wells at closer intervals. We will also look more closely at well cuttings in an effort to determine more precisely the nature of the transition from non-productive to productive rock.

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2.0 FIELD TRIAL

2.1 New Springdale Horizontal Wells

As of April 30, 2005, six wells have been drilled in what is now termed the "Springdale Play" (Figure 5). All six were horizontal, which probed the Brown Niagaran (Figure 6) for about 1000-2000 feet. Subsurface mapping, using data from nearby pinnacle reef wells and well logs, and previous experience piloting horizontal wells were key factors guiding the drill into what is turning out to be a 4-14 foot thick Brown Niagaran section. Measurement while drilling (MWD) technology was employed with the gamma-ray (GR) tool which was key to keeping the bit positioned. The high GR signal from the underlying Gray Niagaran Formation was used as a datum to position the bit.

The trajectories of the six wells projected onto ground surface are shown in Figure 5. No consistent well azimuth has emerged for the play; instead each well is planned based on seismic anomalies supplemented with surface geochemistry and phi-h (porosity thickness) maps based on nearby wells. Further details will be provided in the project final report.

2.2 Surface Geochemistry

The utilization of surface geochemistry has emerged with the Springdale play as an important component for assessing the potential of a proposed well. As mentioned above, the technique is to run a sample line along the proposed well path, using one of several techniques (see below), then analyze for soil gases (C1-C6 +, Figure 7) or microbes (Geomicrobial Technologies). Both techniques give adequate results, with the soil gas analyses being currently favored based on the wider range of data supplied and the robust interpretations based on discriminate analyses using "training wells".

The sampling lines run through March 30, 2005 at Springdale are shown in Figure 5. The microbial results have been previously reported. The soil gas data for one sample are shown in Figure 7 for the State Springdale 7-21 HD well. Note the well-defined gas peaks. Each sample shows some variation over the well path which permits distinction between productive and non-productive rock. This phase is in progress.

Sampling is on-going, with one trip scheduled for May (2005) and a possible (final) trip this fall. Further details on techniques and interpretation will be given in the project final report.

2.3 Sampling Methods

Briefly, the surface geochemistry samples were obtained from shallow (8-inch) shovel holes just below the "A" soil horizon. The samples were collected in glass jars and sent by mail to the Direct Geochemical labs in Denver for analysis.

2.4 Analytical Methods

In the lab, the samples were separated by dry sieving to isolate the <64 micron fraction, which was placed in a 50 ml glass bottle with a septum and heated at 40°C for 24 hours. At that point the headspace gas was extracted by syringe and analyzed by GC/FID. The chromatogram shown in Figure 7 is typical of results obtained.

2.5 Interpretation and Mapping

Direct Geochemical prefers to map anomalies using discriminate analysis in which the C1-C6+ data from samples taken over known reservoirs and non-productive ground are compared statistically. This is essentially a fingerprinting technique that we will need to learn more about and determine if it produces better results. To date, we have not employed such statistical techniques in our data analyses (mainly because the GMT microbial data only yielded one data point per sample) but this appears to be a useful technique and we will investigate it in the time remaining.

3.0 RESULTS AND DISCUSSION

3.1 CAPAC FIELD - A POSSIBLE SPRINGDALE ANALOG

A conceptual model for the Springdale play based on current observations and data is shown in Figure 6. This model assumes that production is mainly from the inter-reef Brown Niagaran in localized pockets that may be small "patch reefs", analogous to the present environment occurring in the Florida Keys.

In addition, it is suggested that a subsurface analog based on data from the Michigan Basin could be Capac Field (Figure 8), located in parts of Lynn and Mussey townships in the northwest corner of St. Clair County (Figure 1). Production at Capac is also from the Brown Niagaran, but unlike many other oil and gas fields in the immediate vicinity, Capac Field is non-reef, similar to Springdale, and is considered a stratigraphic trap (Bowers, 1987). It produces from a thin (4-12 ft.) porous and permeable zone in the otherwise dense and impermeable Brown Niagaran, again similar characteristics to Springdale. Capac is capped by impermeable anhydrite, the A-1 Evaporite, while Springdale is, at least in places, capped by halite. The stratigraphic relations at Capac as deduced by Bowers (*ibid*) are shown in Figure 9, and can be compared to the working model for Springdale depicted in Figure 6. Although neither Capac nor Springdale are proper reefs per se, they both occur in reefal environments and are located in inter-reef positions.

The basic play model is one of porous dolomite encased in impermeable limestone in close proximity to productive reefs. Thus most of the elements necessary for a successful play are present and are essentially the same as for the Pinnacle Reef Play. The major differences between the Pinnacle Reefs and Springdale and Capac appear to be type of trap and the reservoir. The strategy for locating and developing the Springdale Play is also unique, based on using horizontal wells as probes. Further similarities between Capac and Springdale Fields will be developed in subsequent reports, pending study of logs and cuttings.

4.0 CONCLUSIONS

The overall project is on track and appears to be heading for a successful conclusion which will result in significant new production being brought on line, mainly as a result of the Springdale play. In addition, steady progress in application of surface geochemistry has resulted in routine application to proposed new wells in the Springdale play. In the time remaining for this project we will have an opportunity to drill and sample about two more wells in an attempt to further establish the play. To date, an ROI of about 3.75 (Production \$/DOE \$) has resulted.

5.0 REFERENCES

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6.0 FIGURES

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Figure 3. Monthly oil production by well of the Springdale wells in Manistee County, Michigan.

Figure 4. Cumulative and monthly oil production for Springdale wells.

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