FINAL REPORT TO SC, LTR
June 29, 2010

Project No: C9701201, FWP 49398, "The Use of Predictive Lithostratigraphy to Significantly Improve the Ability to Forecast Reservoir and Source Rocks"

Project Status: LTR Funds are expended

Company: Originally with Texaco, Inc. (later **Chevron Corp.**), and the Gas Research Institute (later the **Gas Technology Institute, Inc.**).

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Abstract:

The purpose of this CRADA, which ended in 2003, was to make reservoir and source rock distribution significantly more predictable by quantifying the fundamental controls on stratigraphic heterogeneity. To do this, the relationships among insolation, climate, sediment supply, glacioeustasy, and reservoir and source rock occurrence were investigated in detail. Work current at the inception of the CRADA had uncovered previously unrecognized associations among these processes and properties that produce a phenomenon that, when properly analyzed, will make lithostratigraphic variability (including texture, porosity, and permeability) substantially more understandable. Computer climate simulations of selected time periods, compared with the global distribution of paleoclimatic indicators, documented spatial and temporal climate changes as a function of insolation and provided quantitative changes in runoff, lake level, and glacioeustasy. The effect of elevation and climate on sediment yield was assessed numerically by analyzing digital terrain and climate data. The phase relationships of climate, yield, and glacioeustatic cycles from the Gulf of Mexico and/or other sedimentary basins were assessed by using lacunarity, a statistical technique.

Technical Progress

The technical approach consisted of analyzing proprietary data sets from project partners that subsequently were returned to the project partners. These data sets included:

1. Oil and Gas Fields of the Gulf of Mexico (GRI/GTI)

GRI/GTI provided the project with GIS information with the known location of oil and gas fields in the Gulf of Mexico. The data were assembled on the basis of, in part, permits granted by states (including Texas) and the Federal Government. This data set was developed by using ArcInfo; however, it was converted into a number of forms, including MapInfo, for data processing.

2. Magnetic/Gravity Anomaly Data (Chevron)

Chevron provided both magnetic and gravity anomaly data sets. These data sets were pasteurized results of sensor overflights funded by Chevron. The data sets covered much of the northern Gulf of Mexico and extended inland. The anomalies show, indirectly, the subsurface geological structure of the Gulf of Mexico region. Chevron argued that these data control the distribution of oil and gas fields in the Gulf.

The oil and gas field data were combined with the anomaly data to generate a raster map of both data sets in the same spatial coordinate system. The STRATISTICS package was then used to determine if spatial relationships between the fields and anomalies existed. The primary observation was that a fractal relationship exists on the basis of Lacunarity analysis.

Major Highlights/Accomplishments:

ChevronTexaco recognized the value of this project and continued it outside of DOE after the closeout of the CRADA. The project achieved major successes:

1. STRATISTICS, a high-quality statistical application with a unique combination of statistical methods for use exploration, proved effective for Chevron's internal operations.
2. The modern analyses of river systems, climate, and sediment yield were a major success. With the work conducted at Argonne, Chevron used data mining techniques to show complex relationships among many controls of sediment yield and showed more clearly the role of climate.
3. The successful Permian and Cretaceous climate model runs more clearly defined the impacts of some of the orbital parameters on climate. The results also showed that these impacts can be enhanced or weakened by the geography of continents and presence of ice.
4. In combination, the above successes have made predictions of oil and gas fields easier.

Throughout the project, many lessons were also learned:

1. Researchers generally recognize that climate models are not perfect. However, the project team learned a great deal about the reliability of climate models and recognizing these problems in results.
2. In addition to problems with model reliability, the project team also ran into the problem of support for the models. As is typical with many open source projects, climate models generally do not have good support. As a consequence, the team had trouble configuring the models and even determining whether the models would run the simulations in our plan. For example, Community Climate Model 3 could only do paleoclimate simulations on the SGI supercomputer platform, a platform unavailable to the project.
3. The team also had problems securing time on computers that could run the model. At Argonne, the one computer that could run CCM3 was shut down and an attempt to use a secondary system located at the University of North Carolina was also aborted when that system was also shut down before the team could begin simulations.
4. A system failure also erased about 2 terabytes of climate model results at Argonne. Although the data lost did not prove important, the team learned the importance of maintaining more

redundancy between project member roles. Later model results were backed up and distributed to Chevron to prevent data loss.

5. STRATISTICS, although a cutting-edge application, suffers from a graphical user interface (GUI) that is not designed for real users. With a partnership with a software development company, the GUI could be refined.

Project Related Publications (Partial List)

- Moore, T.L., M.A. Perlmutter, and C.R. Scotese, 2005, *Global and Regional Impacts of Orbital Cycles on the Climate and Sedimentation of Icehouse and Greenhouse Worlds*, AAPG 2005 Convention Abstracts, http://www.searchanddiscovery.com/documents/abstracts/2005annual_calgary/abstracts/moore02.htm
- Perlmutter, M.A., R. Plotnick, and T. Moore, 2005, *The Impact of High-Frequency Climate Cycles on Exploration Strategy*, AAPG 2005 Convention Abstracts, http://www.searchanddiscovery.com/documents/abstracts/2005annual_calgary/abstracts/perlmutter.htm
- Moore, T.L., R.E. Plotnick, R.J. Oglesby, M.A. Perlmutter, and K. Maasch, 2001, *Quantitative Climate Model/Paleoclimate Indicator Comparisons*, Abstracts with Programs of the Geological Society of America, V. 33, No. 6, p. 22.
- Moore, T.L., R.J. Oglesby, M.A. Perlmutter, M.D. Matthews, R.E. Plotnick, and K.A. Maasch, 2000, *Deciphering Orbital Maximum and Minimum States During The Pleistocene*, Abstracts with Programs of the Geological Society of America, V. 32, No. 7, A95.
- Perlmutter, M.A., M.D. Matthews, T.L. Moore, R.E. Plotnick, and R.J. Oglesby, 2000, *Climatic Extremes and Response of the Global Depositional System*, V. 32, No. 7, p. A313.