Seismic Determination of Reservoir Heterogeneity: Application to Characterization of Heavy Oil

DE-FC26-00BC15301

Program

This project was selected in response to DOE's Oil Exploration and Production FY2000 solicitation DE-PS26-01NT41048, for Critical Upstream Advanced Diagnostics and Imaging Technology. The solicitation goal was to continue critical upstream cross-cutting, interdisciplinary research for the development of advanced and innovative technologies for imaging and quantifying reservoir rock and fluid properties to improve oil recovery.

Project Goal

The project goal was to examine how seismic and geologic data can be used to improve characterization of small-scale heterogeneity and their parameterization in reservoir models.

Performers

Virginia Polytechnic Institute and State University
Blacksburg, VA

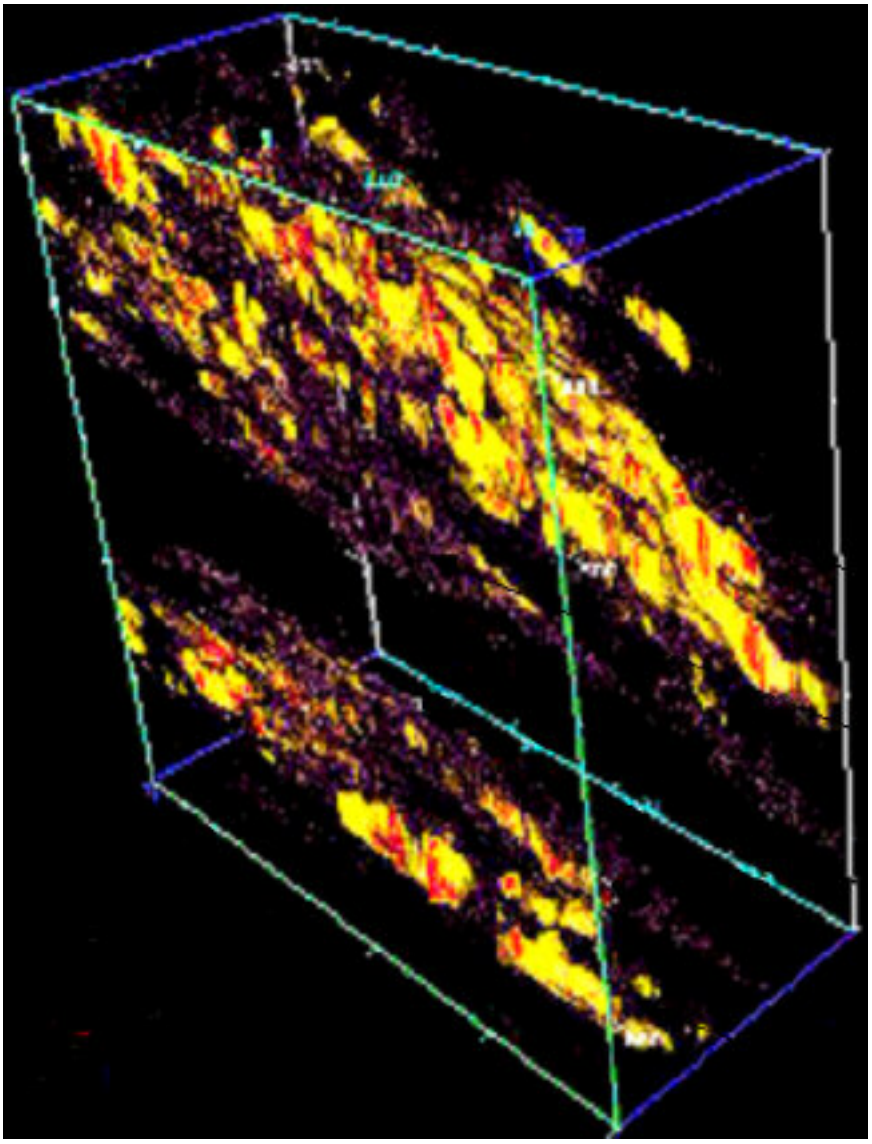
Clemson University
Clemson, SC

Chevron Corp.
San Ramon, CA

Project Results

For the complex Coalinga oilfield in central California's San Joaquin Valley, researchers developed a thorough understanding of reservoir evolution through geologic time, both conceptually and practically, which provided a framework allowing integration of different data and techniques.

This framework was built by interpreting outcrops, cores, wireline, and seismic data. The project then progressed through a sequence of heterogeneity models, starting with simple wireline log interpolation. It continued with geostatistical models based on wireline data and/or seismic data and ended up with a modeling technique that integrated seismic and wireline data through a lengthy optimization process.



Excerpt of the seismic data: Yellow seismic facies represent reservoir sands in the Temblor Formation at Coalinga Field, San Joaquin Valley, CA, deposited in an incised valley (bottom) and in a subtidal environment (top). The block shown is 1 by 3 miles.

Benefits

New methods were developed and tested to determine reservoir heterogeneities based on seismic and geologic data. The information provides an improvement on interwell interpretations of reservoir properties and fluid flow. The project resulted in development of a seismic heterogeneity attribute, which was implemented in an optimization algorithm for object-based reservoir models and finally developed into a geological framework for data integration.

Background

Improved prediction of interwell reservoir heterogeneity is imperative to enhancing hydrocarbon productivity as well as reducing economic and environmental costs for California's heavy oil sands in the San Joaquin Valley.

Project Summary

The objective of the project was to examine how seismic data can be used to improve characterization of small-scale heterogeneity and their parameterization in reservoir models.

The project originally contained seven major parts: 1) preconditioning of seismic data, 2) well-ties and construction of deterministic framework, 3) poststack interpretations, 4) variogram-based prestack estimation of heterogeneity, 5) object-based

poststack estimation of heterogeneity, 6) comparisons against independent heterogeneity models, and 7) integration of geological and geophysical models.

Researchers also attempted to build independent reservoir models based on different geologic and geophysical data and different tools. This rigid beak-up into phases proved to be ineffective, however, and a more flexible and integrated approach was taken. Throughout the project, researchers learned that this strategy was impractical because the different data and model are complementary instead of competitive. The different methods and models required qualitative and quantitative information obtainable from others, which renders the process iterative instead of linear. For example, the seismic interpretation in the traditional sense was the foundation of the project, but it also was continuously updated and refined, and the results were used to segment and constrain other models.

Current Status (October 2005)

The project is complete, and a number of dissertations and publications have resulted from the project.

Publications (partial list)

Mize, K.L., Development of Three-Dimensional Geological Modeling Methods using Cores and Geophysical Logs, West Coalinga Field, CA, MS thesis, Clemson University, 2002.

Piver, J.L., Integration of Geologic Models and Seismic Data to Characterize Interwell Heterogeneity of the Miocene Temblor Formation, Coalinga, California, MS thesis, Clemson University, 2004.

Nowak, E., Applications of the Radon Transform, Stratigraphic Filtering and Objected-Based Stochastic Reservoir Modeling, PhD dissertation, Virginia Tech, 2004.

Mahapatra, S., Seismic Reservoir Characterization of Coalinga Field, PhD dissertation, Virginia Tech, 2005.

Imhof, M.G., Scale Dependence of Reflection and Transmission Coefficients, Geophysics, 68(1), 322-336, 2003.

Imhof, M.G., and Kempner, W., Seismic Heterogeneity Cubes and Corresponding Equiprobable Simulations, Journal of Seismic Exploration, 12(1), 1-16, 2003.

Nowak, E., Imhof, M.G., and Kempner, W., Object-Based Stochastic Facies Inversion, Computers & Geosciences, submitted 2005.

Project Start: September 1, 2000
Project End: August 31, 2004

Anticipated DOE Contribution: $450,000
Performer Contribution: $202,560 (45% of total)

Contact Information

NETL – Paul West (paul.west@netl.doe.gov or 918-699-2035)
Virginia Tech – Matthias G. Imhof (mgi@vt.edu or 540-231-6004)