

Improving Geologic and Engineering Models of Midcontinent Fracture and Karst-Modified Reservoirs Using New 3-D Seismic Attributes

DE-FC26-04NT15504

Goal

The project goal is to develop innovative seismic-based methodologies and workflows for the incremental recovery of hydrocarbons from karst-modified carbonate reservoirs within the onshore continental United States. The project objectives are to 1) calibrate new multi-trace seismic attributes for improved imaging of hydrocarbon reservoirs, 2) develop attribute-based, cost-effective workflows to better characterize karst-modified carbonate reservoirs and fracture systems, and 3) to improve accuracy and predictiveness of geomodels and reservoir simulations.

Performers

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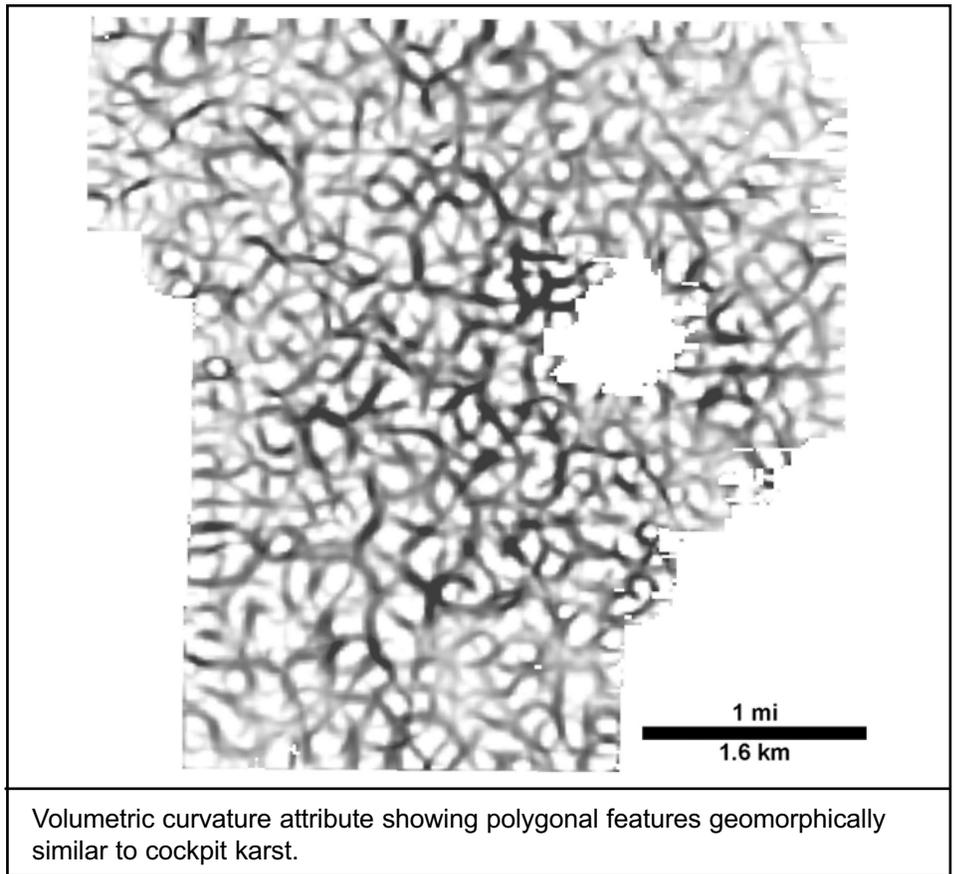
Results

The project achieved the following:

- A catalog of karst features imaged with 3-D seismic attributes and calibrated with geological and engineering data was developed, providing analogs to other karst-modified reservoirs. It's available online at <http://www.kgs.ku.edu/SEISKARST/catalog.html>.
- Integrated workflows are being developed to effectively utilize new seismic attribute technology in the exploration, development, and management of karst-modified reservoirs.

Benefits

Successful application of the new workflows developed in this project has the potential to increase incremental recovery of hydrocarbons from karst-modified reservoirs within the onshore continental United States and may allow more-accurate assessment of karst-modified reser-



voirs elsewhere in the world.

Background

Karst-modified carbonate reservoirs account for 30-50 percent of the hydrocarbon production in the U.S. Midcontinent. These reservoirs are often characterized by low matrix permeability, fluid control problems, and low hydrocarbon recoveries. Fractures are one of the most important controls on development of permeability and hydraulic flow units in karst reservoirs. New technology is critical to the optimization of karst-modified reservoirs, and the project's new multi-trace, geometric seismic attributes have the potential to image karst sinkholes, field-scale fracture systems, and other usually elusive subseismic features in relatively low-cost, conventionally acquired 3-D seismic surveys. In order to advance this imaging technology for the development and management of karst-modified reservoirs, these attributes must be calibrated at the reservoir scale. In this project, researchers are calibrating attributes from three Midcontinent karst-modified reservoirs (in West Texas, Colorado, and Kansas) that represent a wide diversity of karst types and will validate their results through reservoir simulation.

Summary

The following results were obtained during the second year of the project:

- Interpretation of multi-trace seismic volumetric curvature attributes in the study areas has revealed a variety of karst features (including collapse features and geomorphologies that appear to be related to mature, cockpit landscapes), which provides the building blocks for a seismic attribute catalog of karst features.
- A catalog of karst features displays initial results of the 3-D seismic attribute analysis for the study areas, augmented with examples from other areas. The catalog illustrates the utility of volumetric curvature attributes to reveal previously unknown features in the seismic data or to provide enhanced visibility of karst features compared with other seismic analysis methods.
- In all study areas, seismic curvature attributes illuminate lineaments that appear to be related to joint and fracture systems controlled by regional structure.
- Integrated reservoir characterization studies, making use of complementary seismic, geological, petrophysical, and

engineering data, are in progress for all study areas.

- Improved interpretations involve using a moving subvolume about the point to minimize spurious events and extract time slices and/or horizon slices from volumes. Interpretations also use fractional derivatives to investigate multiple wavelengths of curvature, thereby allowing better imaging of irregular karst features.

- Synthesis of seismic attribute analysis with core, production, and tracer data in the West Texas study area indicates that, in this reservoir, lineaments imaged by curvature attributes are related to late stage fracturing and dissolution of anhydrite-cemented karst fractures and can be correlated with localized high volumes of water production.

- The project website (<http://www.kgs.ku.edu/SEISKARST>) provides timely, wide-audience dissemination of information related to the project.

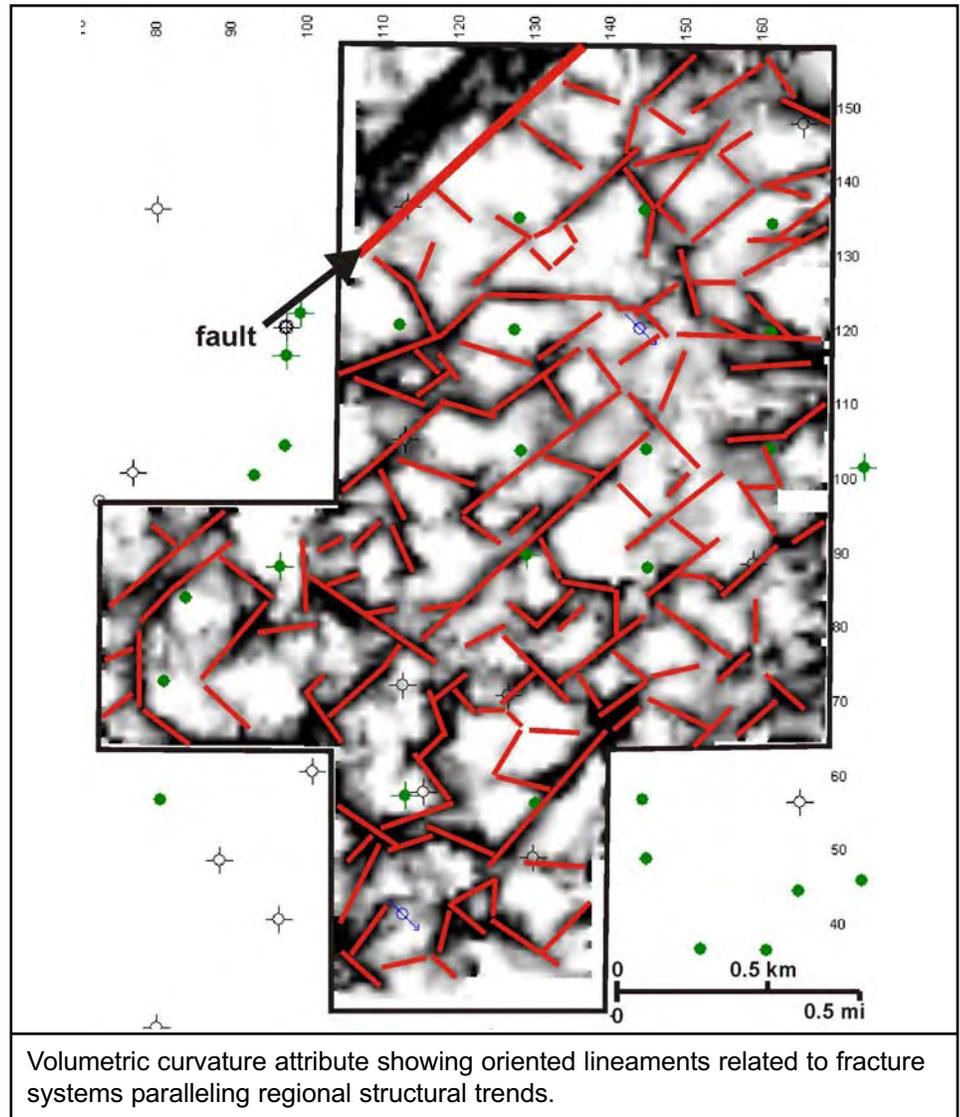
- Abstracts have been submitted for presentations at regional and national conferences.

Current Status (February 2007)

The third year of this project began in October 2006. A no-cost extension was granted.

Funding

This project was selected in response to DOE's Oil Exploration and Production solicitation DE-PS26-04NT15450-2A.



Volumetric curvature attribute showing oriented lineaments related to fracture systems paralleling regional structural trends.

Publications

Nissen, S., Sullivan, E.C., Marfurt, K.J., and Carr, T.R., "Improving Reservoir Characterization of Karst-Modified Reservoirs with 3-D Geometric Seismic Attributes," abstract, AAPG 2007 Midcontinent Convention.

Nissen, S., Carr, T.R., and Marfurt, K.J., "Improving Reservoir Using New 3-D Seismic Attributes to Identify Subtle Fracture Trends in Mid-Continent Mississippian Carbonate Reservoirs," RMAG/DGS 3-D Seismic Symposium 2007.

Nissen, S., Carr, T. R., Marfurt, K. J., and Sullivan, E. C., Using 3-D Seismic Volumetric Curvature Attributes To Identify Fracture Trends In A Depleted Mississippian Carbonate Reservoir: Implications For Assessing Candidates For CO2 Sequestration, AAPG Memoir CO2 Sequestration, in press 2007.

Dou, Q., Sullivan, E.C., and Marfurt, K., "Seismic Geomorphology of Unconformities in the Guadalupian (Permian) Grayburg and San Andres Formations, Eastern Central Basin Platform, West Texas, USA," abstract, AAPG 2006 Annual Convention.

Givens, N.B., and Nissen, S., "Karst and fracture features affecting reservoir performance in a Mississippian reservoir, Cheyenne County, Colorado," abstract, AAPG 2006 Annual Convention.

Nissen, S.E., Givens, N.B., Doveton, J.H., Byrnes, A.P., Rocke, B.J., Bhattacharya, S., and Sullivan, E.C., Semi-Annual Scientific/Technical Report, May 2006, http://www.kgs.ku.edu/SEISKARST/DE_FC26_04NT15504_May06_semiannual.pdf.

Givens, N.B, and Nissen, S.E., "Fracture and Karst Features Affecting Reservoir Performance in a Mississippian Reservoir, Cheyenne County, Colorado," KGS 2006-14, <http://www.kgs.ku.edu/SEISKARST/transfer.html>.

Sullivan, E.C., Nissen, S.E., Marfurt, K.J., and Blumentritt, C.H., "Application of New Seismic Attributes to Identify Karst and Fracture Related Compartmentalization: Permian San Andres Formation, Central Basin Platform, West Texas (USA)," presented at AAPG Convention, April 2006, and at DGGS Expo, May 2006.

Project Start: October 1, 2004

Project End: January 31, 2008

Anticipated DOE Contribution: \$799,833

Performer Contribution: \$297,770 (27 percent of total)

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