Time-Lapse Seismic Modeling and Inversion of CO_2 Saturation for Sequestration and Enhanced Oil Recovery

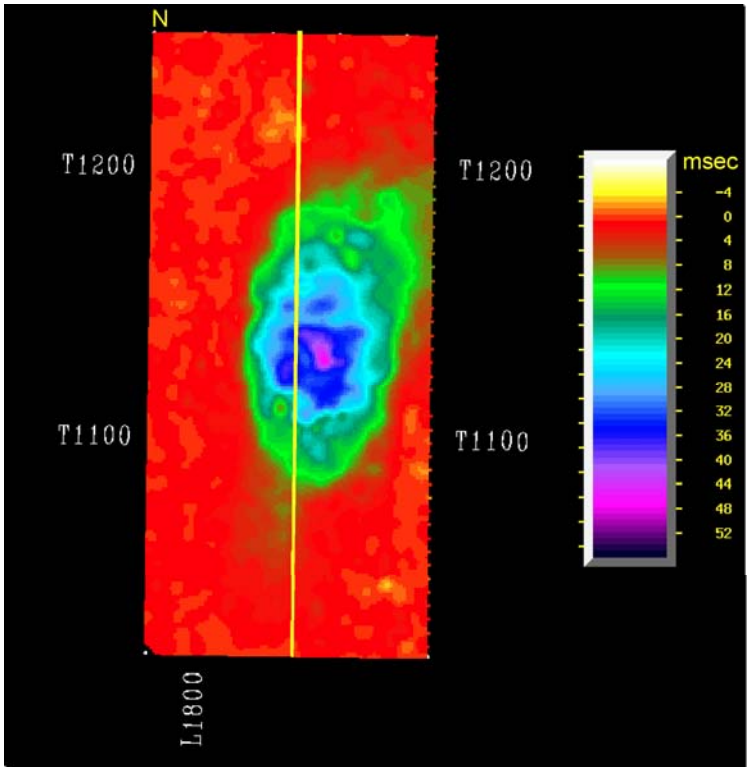


Image shows a Seismic Travel-Time Difference Map Produced from Two Vintages of the Sleipner Field, North Sea, CO_2 Seismic Dataset.

Objectives of the Project:

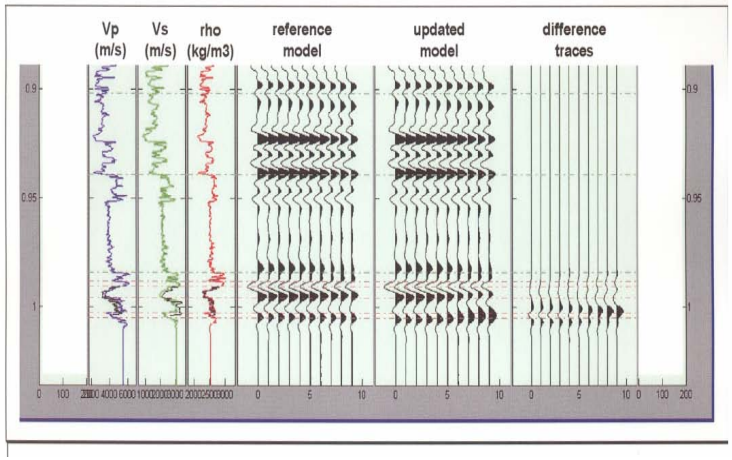
- Improve current methods of time-lapse seismic reflection modeling for carbon dioxide sequestration and miscible CO_2 floods in oil and gas reservoirs and to develop new strategies to invert such data to estimate changes in pressure and CO_2 saturation over time
- From seismic reflection data project is to determine CO_2 saturation during field flood
- Equation of state (EOS) formulated to calculate Fluid properties

4th Wave Imaging Corp

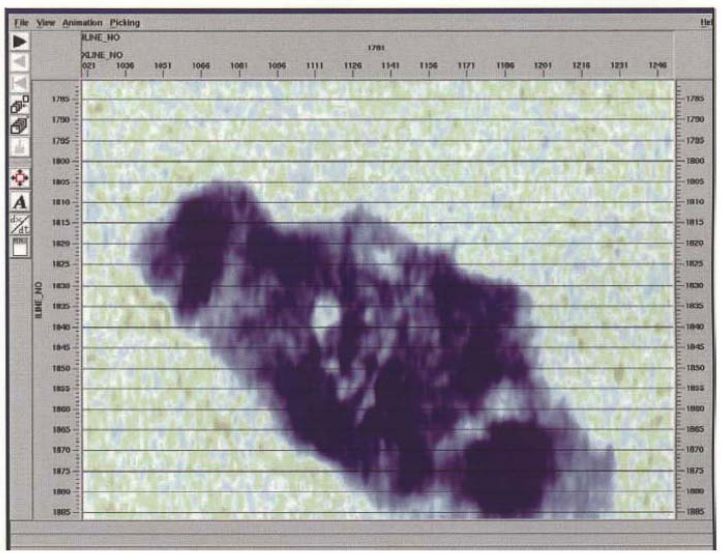
DE-FC26-03NT15417

Source: 4th Wave Imaging

Time-Lapse Seismic Modeling and Inversion of CO_2 Saturation for Sequestration and EOR



Seismic Processing Differences between Original Model of Reservoir and Updated Seismic Processed Model



Time-Lapse CO_2 Seismic Data set showing a Clear Amplitude Anomaly Caused by Increasing CO_2 Saturation

Source: 4th Wave Imaging

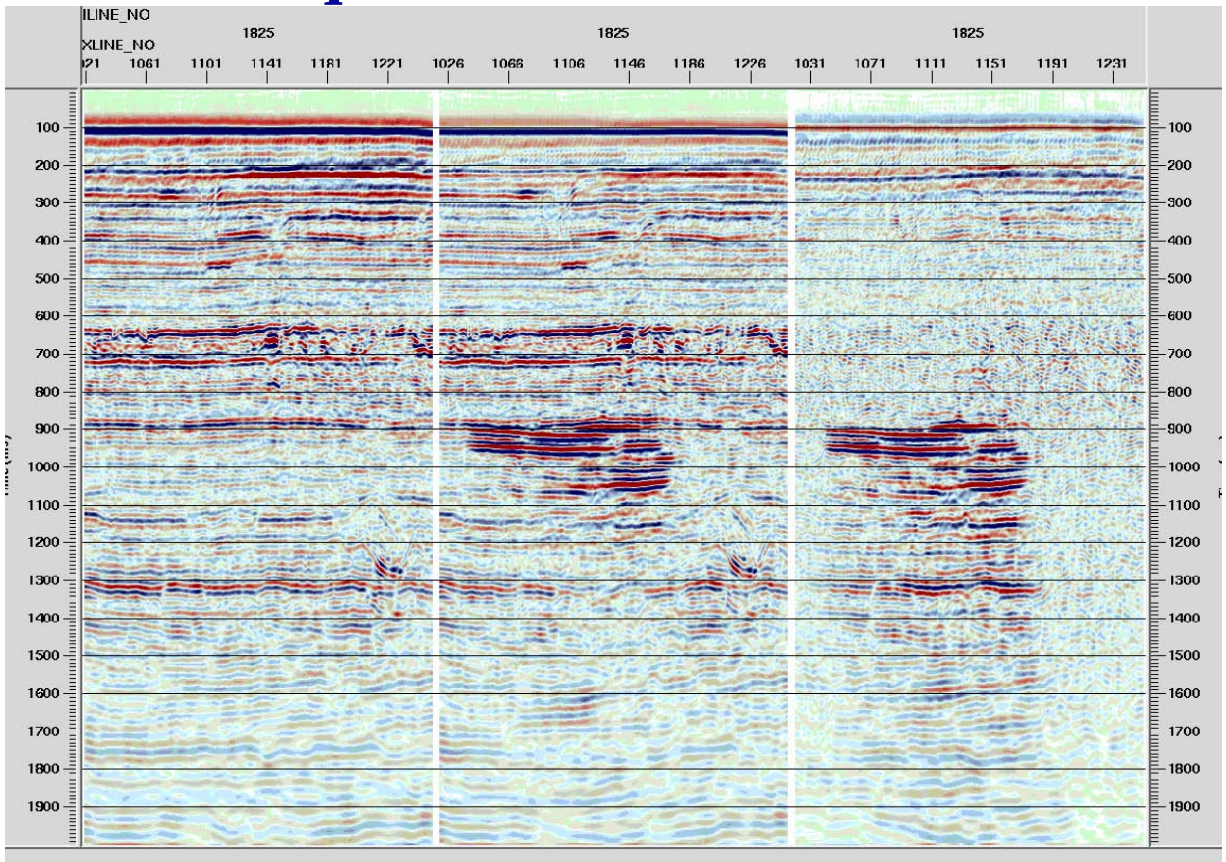
Time-Lapse Seismic Modeling and Inversion of CO_2 Saturation for Sequestration and Enhanced Oil Recovery

Results of the Project:

- New algorithms developed to model accurately time-lapse seismic changes during CO2 injection, and to invert these data to estimate changes in reservoir properties, such as pressure and CO_2 saturation, that cause the seismic anomalies. Both modeling and inversion algorithms rely on rock physics relations to estimate seismic parameters, such as velocities and densities, as a function of CO_2 saturation and pressure. The major achievements of this project include:
- New ways to compute fluid properties of oil-water-CO_2 mixtures.
- Development of a 1-D time-lapse well-log modeling program.
- Developed algorithm to generate time-lapse seismic attribute changes as a function of changes in CO_2 saturation and pressure.
- New tools to invert time-lapse seismic anomalies to yield estimates of CO2 saturation and pressure changes and calibration of these tools on a synthetic dataset.
- Quantification of time-lapse seismic anomalies from different vintages of a 3-D data set from Sleipner gas field in the Norwegian North Sea.

Source: 4th Wave Imaging

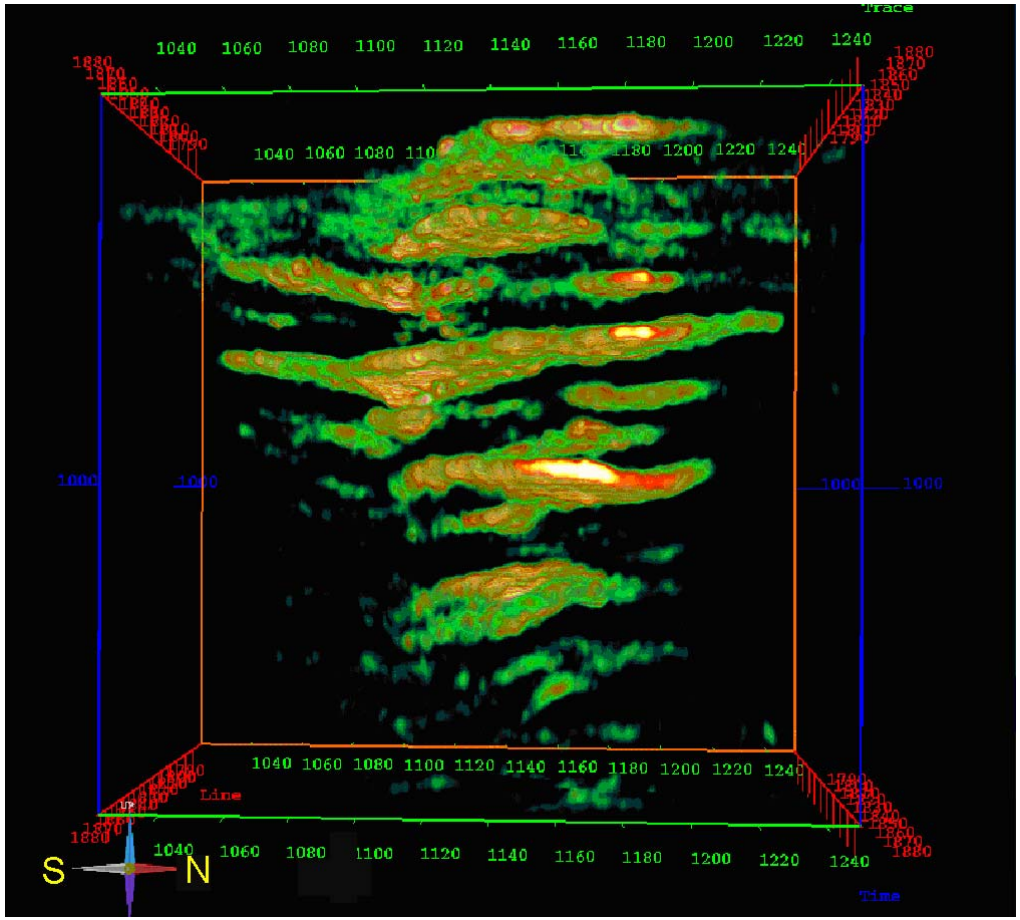
Time-Lapse Seismic Modeling and Inversion of CO_2 Saturation for Sequestration and Enhanced Oil Recovery



Seismic stacked sections from the Sleipner Time-Lapse CO_2 project, Norwegian North Sea. Vertical sections are taken from the 1994 (left), 2002 (middle), and 2002-1994 difference (right) cubes. Clear evidence of a time-lapse anomaly is visible in the difference section starting at around 900 msec. CO_2 injection started in 1996.

Source: 4th Wave Imaging

Time-Lapse Seismic Modeling and Inversion of CO_2 Saturation for Sequestration and Enhanced Oil Recovery



3-D perspective view of seismic reflection amplitudes from the 2002 Sleipner North Sea data set. Clouds of high-amplitude values delineate the location and extent of the CO_2-saturated zones within the Utsira sand

Source: 4th Wave Imaging

Time-Lapse Seismic Modeling and Inversion of CO_2 Saturation for Sequestration and Enhanced Oil Recovery

Publication of the Project:

- As of December 20, 2005, this project has not produced any publications resulting from this research.

Source: 4th Wave Imaging