Testing Advanced Computational Tools for 3D Seismic Analysis Using the SEG/EAGE Model Dataset

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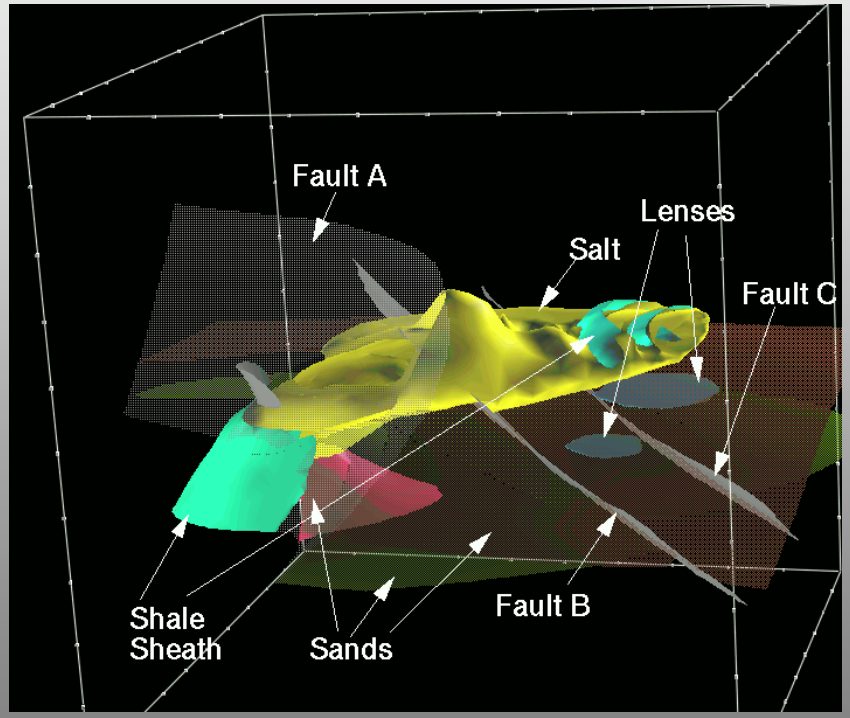
Demonstrating the usefulness of the SEG/EAGE acoustic model data set

Project Objectives

- Develop, test new 3-D seismic methods for
  - Imaging
  - Modeling
- Get new methods to industry participants
- Publicize, show usefulness of SEG/EAGE Numerical Data Set

Project Tasks

- Cost-Effective Imaging
- Elastic Numerical Modeling
- Physical Modeling
- Unconventional Analysis



Participants

- **Industry (25)**
  - Advanced Data Solutions, Anadarko, ARCO, BHP Petroleum, BP Amoco, Burlington Resources, Chevron, Conoco, Edison Chouest Offshore, Exxon, GECO-Prakla, Fairfield Industries, Marathon, Mitchell Energy, Mobil, Paradigm Geophysical, PGS-Tensor, Phillips, Shell, Silicon Graphics/Cray, Texaco, Union Pacific Resources, Unocal, Western Geophysical
- **National Laboratories (3)**
  - Los Alamos, Lawrence Livermore, Oak Ridge
- **Universities (4)**
  - HARC/Rice University, Stanford University, University of California at Davis, University of Houston
- **Industry Liaison (4)**
  - Chuck Burch, Bob Wiley, Ken Kelly

Project Accomplishments

- New, Faster 3-D Imaging: Common Azimuth Imaging
- 3-D Elastic Modeling Code, Benchmark Examples
- Physical Model Data and Imaging
- Automated Event Picking and Tracking
- Global Optimization of Residual Statics
- Publications

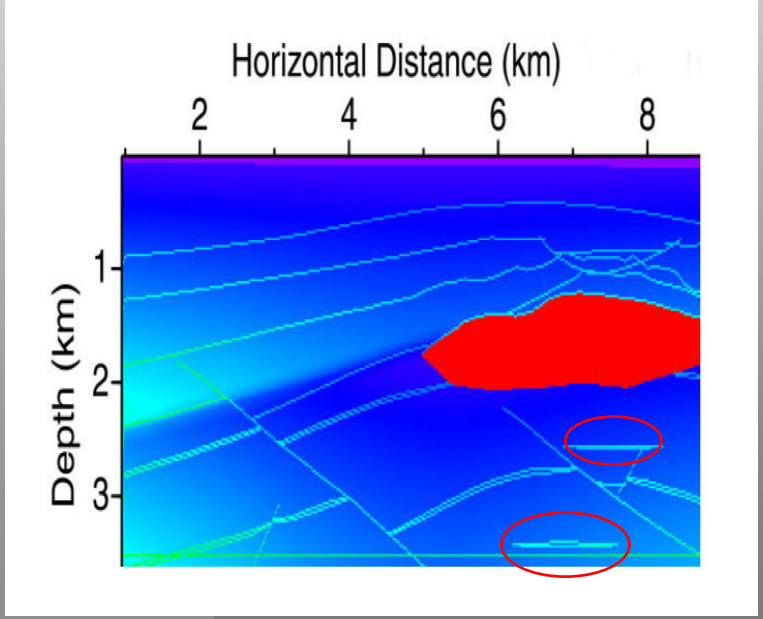
Cost-Effective Imaging: Accomplishments

- Developed, tested, faster wave-equation based imaging method (common-azimuth imaging)
- Better than conventional Kirchhoff imaging: more real image features, fewer artifacts
- Computing time comparable to Kirchhoff

Common-Azimuth Imaging

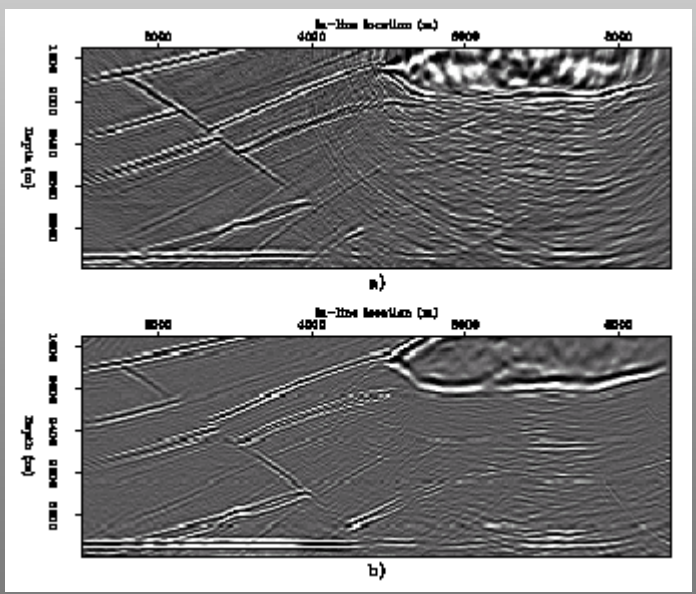
Compare to conventional Kirchhoff

Sand lenses (red ovals) below salt are extremely difficult to image



Conventional Kirchhoff (top)

Common Azimuth (bottom)



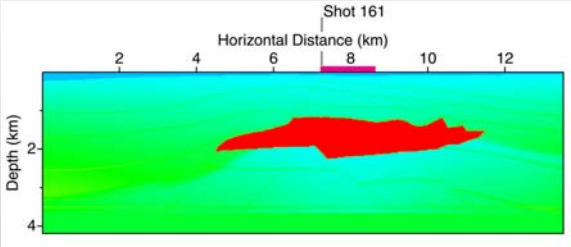
From Biondi, et al, 1999 (Rio ‘99)

3-D Elastic Numerical Modeling

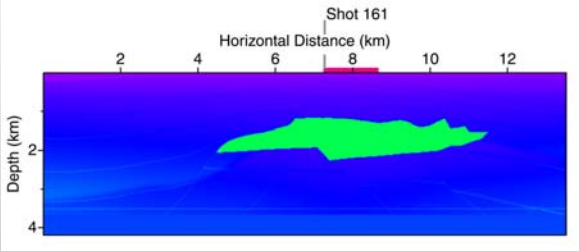
- **Why?**
  - **Test imaging methods (single, multi-component)**
  - **Calibrate processing, interpretation algorithms (AVO, attributes)**
- **Accomplishments**
  - **Developed, tested efficient, versatile modeling code (E3D)**
  - **Industry tested and validated**
  - **Computed benchmark examples**

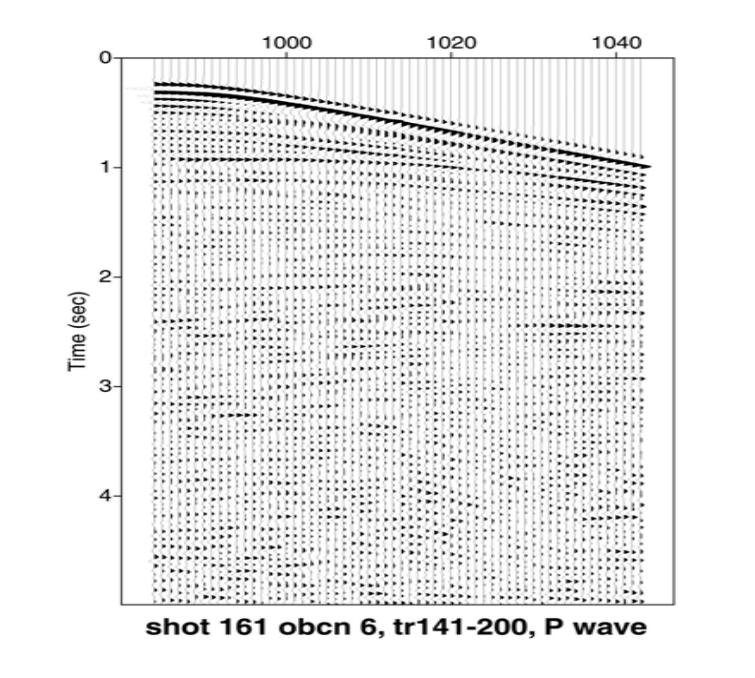
Elastic Numerical Modeling:
Example Calculation (Shot Gathers)

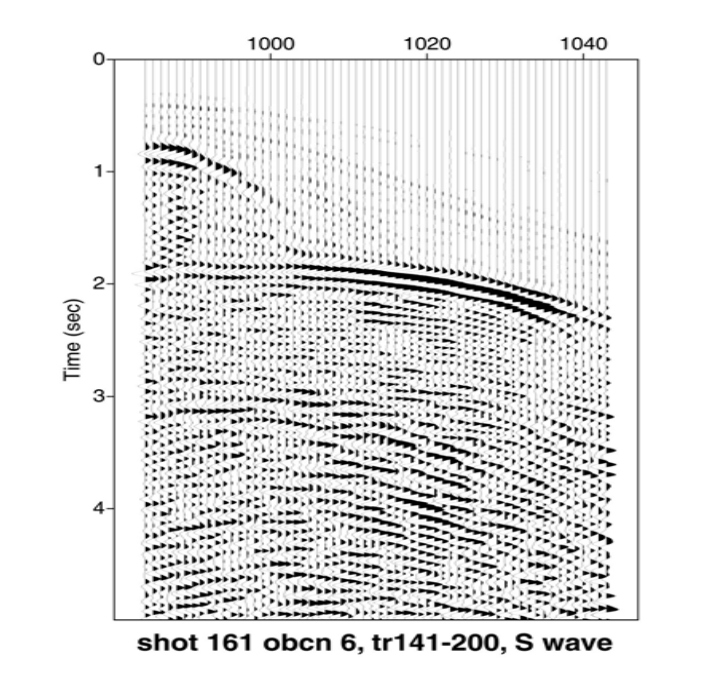
P Wave



S Wave

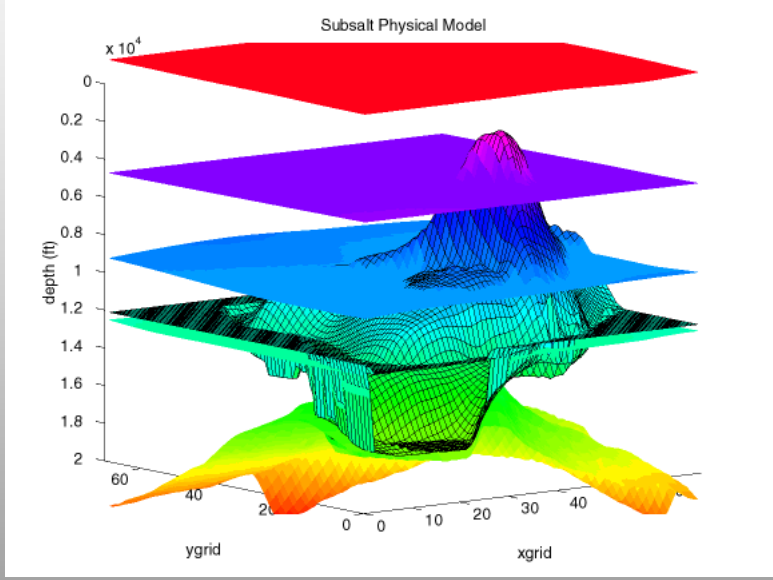






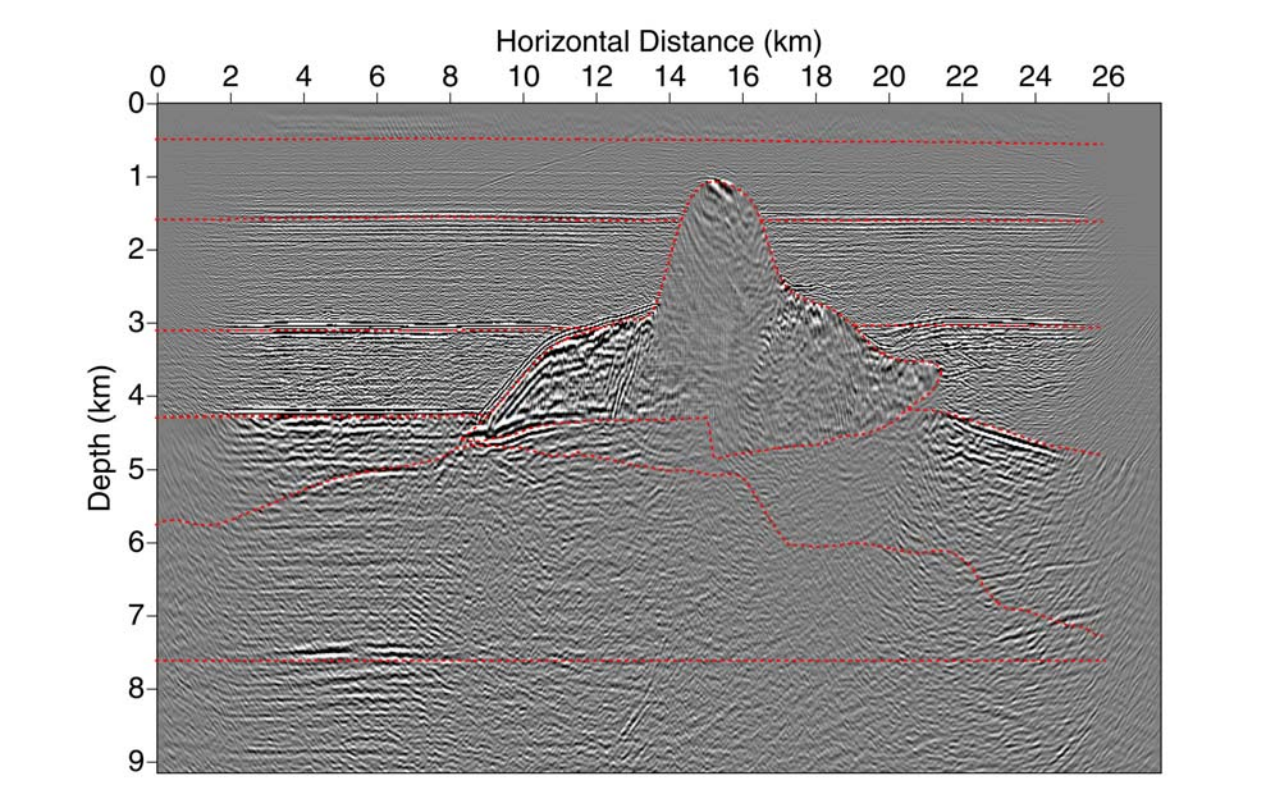
Physical Model

- Imaging and Modeling A Physical Model of SEG/EAGE Salt Structure
- Accomplishments
  - Refined, validated velocity structure
  - 3-D imaging of marine survey
  - 3-D modeling of marine survey



Physical Modeling: Imaging of Marine Cable Data

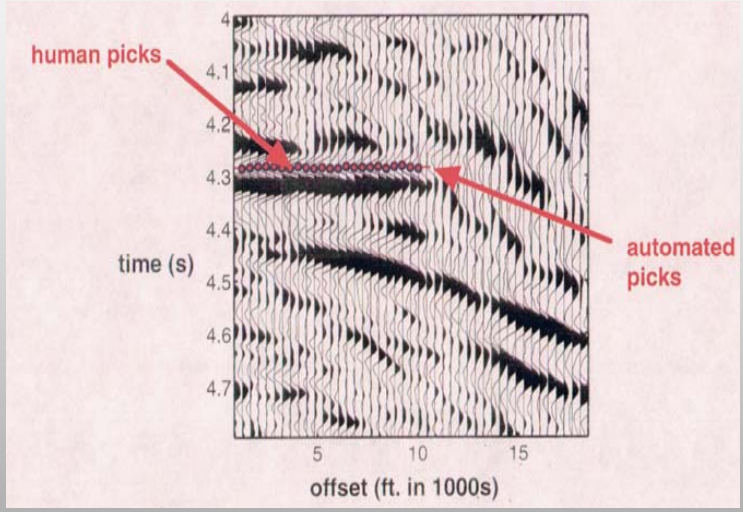
- 3D: Good to top salt, portions of base salt



- Line 351
- 3,600 CPU hrs, SGI/Origin
- 369 shots (of 740)
- wave-equation imaging

Unconventional Methods:
3-D event picking and tracking

Automated event picking and tracking in 2-D and 3-D data



Accomplishments

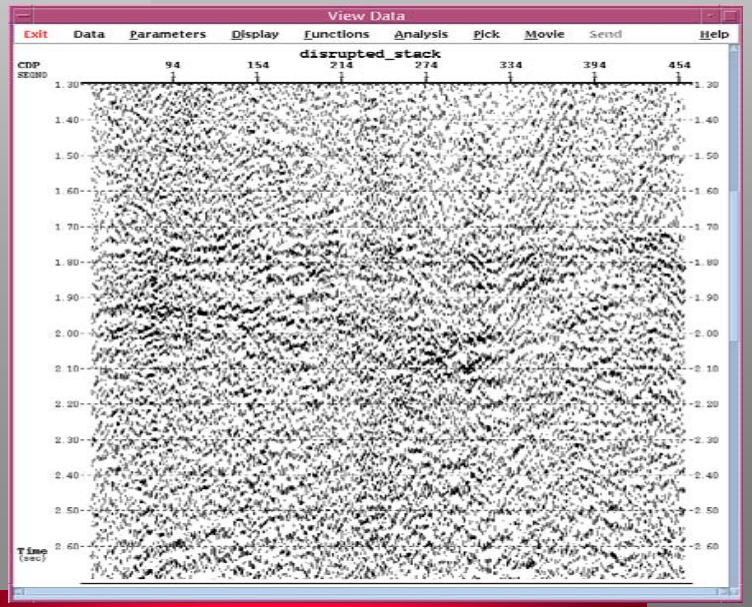
- 2-D method developed, tested, put in production
- Developed, testing 3-D method
- Validate 3-D picks with methods from computer vision research (“deformable contours”, “snakes”)
- Transfer methods to project participants

Unconventional Methods:
New Global Inversion Method

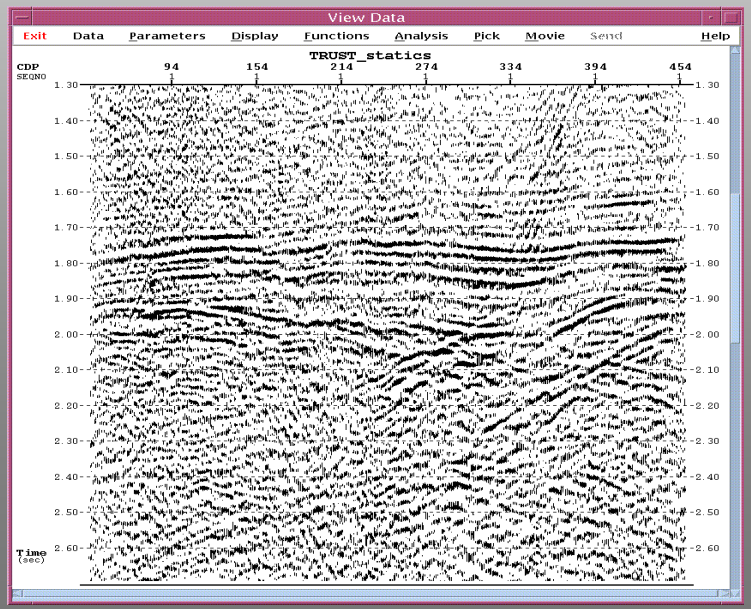
Accomplishments

- **Refined method (TRUST) (faster, more reliable)**

Before



After



Project Plans

- Make Wave Equation Imaging Practical
- Elastic Numerical Modeling Benchmark Calculations
- Image and Compare Physical Model Data Sets (marine, vertical cable)

Application of Results

- Faster, more reliable 3-D imaging
- Standard for 3-D Elastic Modeling
- Physical model data sets, imaging
- Faster, more reliable 3-D velocity analysis, interpretation
- Robust solution to statics

Benefits & Value to Industry

- Reduce exploration risk, improve success (GOM exploration well costs millions $)
- 3-D Imaging up to 50 times faster
- Proven code for numerical modeling
- Reduce cost of 3-D velocity analysis by 92%, time by 12 times

Project Problems

- Industry Downsizing and Consolidation
- Broad scope project
- Number of participants
- Limited funding
- Requirement for electronic transfer of SEG/EAGE data set

Conclusions

- Success with new methods of imaging, modeling
- Tech transfer of new methods
- Publicize results
- New project startup
- SEG/EAGE numerical model data is a standard test data set for imaging