

# Seismic Modeling, Migration and Velocity Inversion

## Canadian Foothills

Bee Bednar

Panorama Technologies, Inc.  
14811 St Marys Lane, Suite 150  
Houston TX 77079

May 18, 2014



# Outline

## 1 Canadian Foothills

- Location and Prospect Type
- The Early Days
- The Importance of Topography
- Yan and Lines Geophysics 2000
- Wells and Anisotropy — Vestrum Geophysics 2006

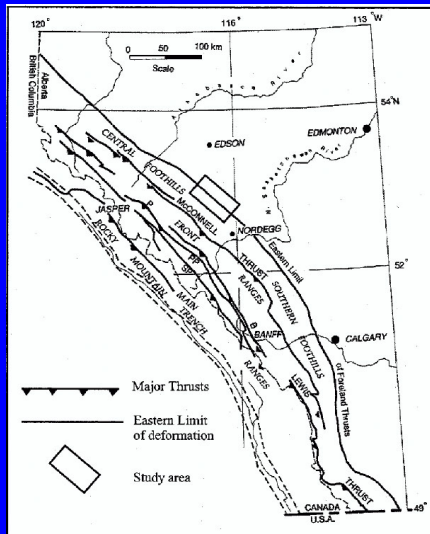
# Outline

## 1 Canadian Foothills

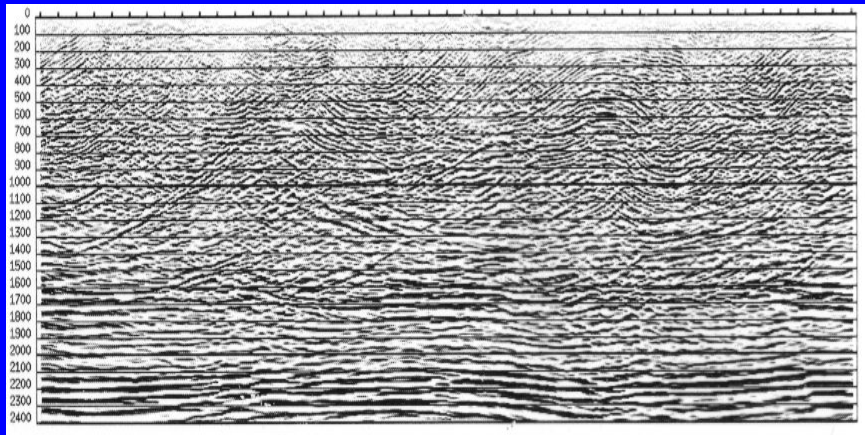
- Location and Prospect Type
- The Early Days
- The Importance of Topography
- Yan and Lines Geophysics 2000
- Wells and Anisotropy — Vestrum Geophysics 2006

# Foothills Location Map

- Compressional thrust system
- Nordegg, Viking, ...
  - $\approx 10,000,000$  MCF/day
- 2.5 dimensional structure
  - Out-of-plane negligible
  - Long 2D lines
  - Fine sampling
  - Long recording times
  - 3D very use full
- Steep dips shallow
- Flat events deep
- Velocity follows structure
- Strong anisotropy
  - Time imaging difficult
  - Lateral misplacement



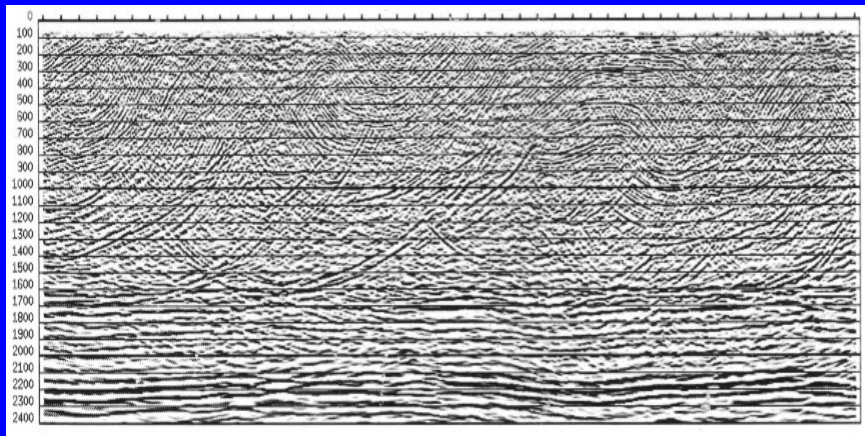
# Typical Kirchhoff PSTM



Typical Kirchhoff PSTM around 1989-1990. Rapid lateral velocity change makes imaging difficult. Target is below the triangle zone in the right hand side of the figure.

Panorama  
Technologies

# Typical Kirchhoff PSDM

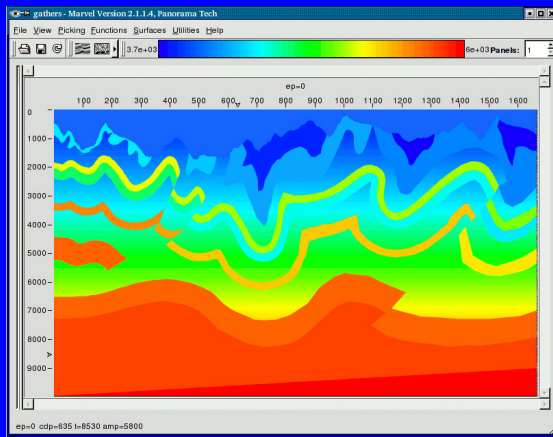


Typical Kirchhoff PSDM from datum around 1990-1993. Superior to PSTM only in that the right hand side triangle zone is somewhat better imaged.

# Issues

- Poor pre-processing?
- Poor Velocity model?
- Refraction Statics?
- Poor Near Surface Model?
- Topography?
- All of the above?

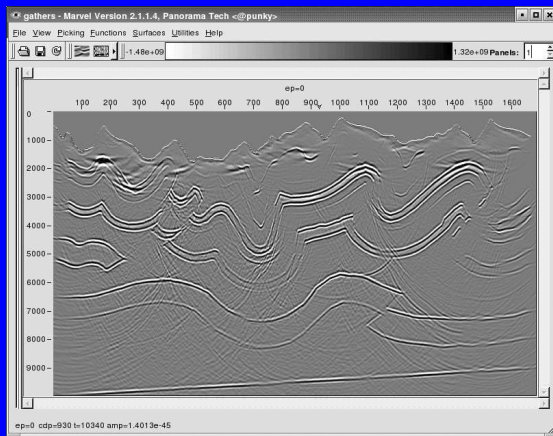
# Canadian Foothills Thrust Model



BP's 2004 Canadian foothills thrust model

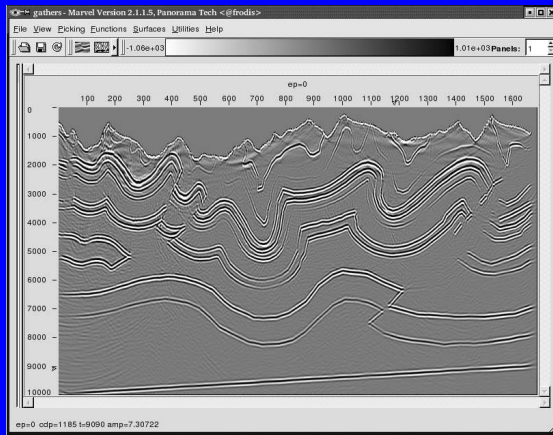


# Canadian Foothills Thrust Model



Kirchhoff topographic migration of BP's 2004 Canadian foothills thrust model data.

# Canadian Foothills Thrust Model



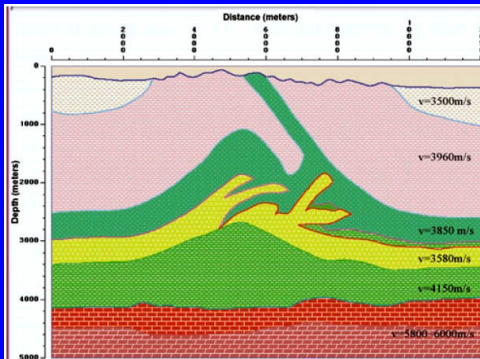
Full two-way topographic migration of BP's 2004 Canadian foothills thrust model data

# NE-SW 2D Exploration Line

- 240 channel split spread
- 4 seconds at 2 ms
- 25m group
- 100m shot
- Near offset 25m
- Far offset  $\approx 3000\text{m}$

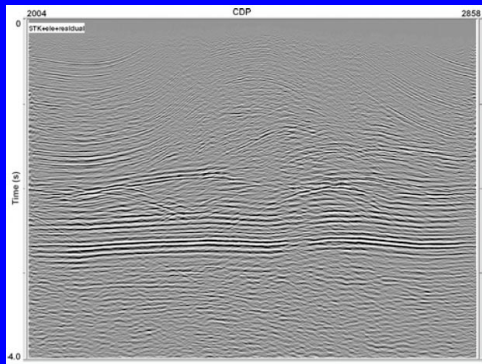
# The Initial Well Derived Model (Mobil)

- Initial well derived model
  - Interpreter's view
  - Not a good idea
  - Not  $v_{nmo}$



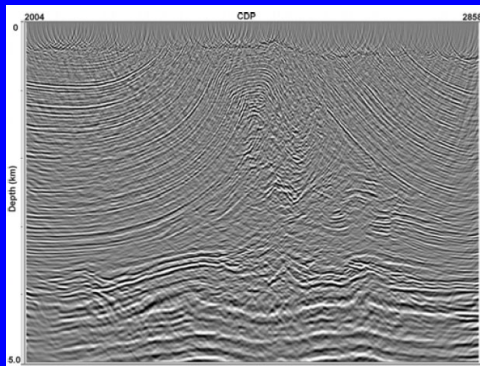
# Pre-processed Stack

- Pre-processing
  - t-squared gain
  - Elevation statics
  - Residual statics
  - Surface consistent deconv



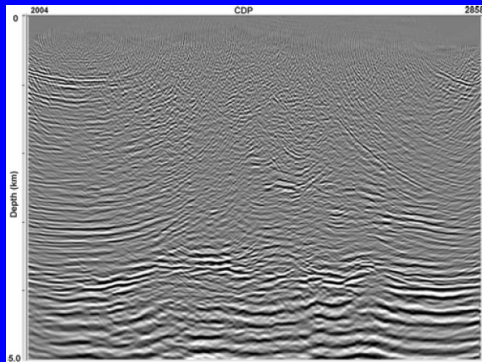
# Poststack Depth of Stacked Section

- Initial Mobil model
- From datum



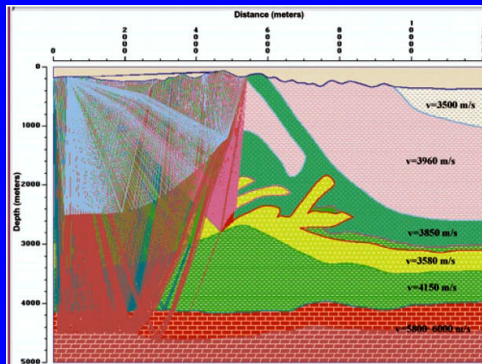
# Prestack Depth with Initial Model

- Model?
- Algorithm?
  - Depth doesn't work
- Pre-processing



# Modeling for algorithmic testing

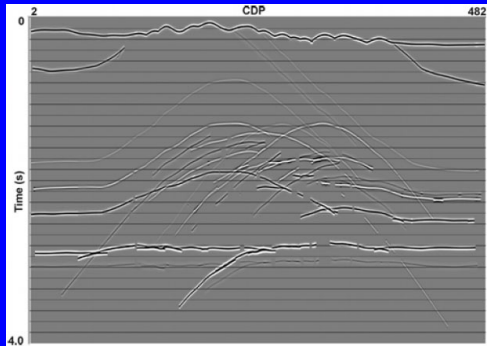
- Generate synthetic
  - By raytracing
- Verify algorithms





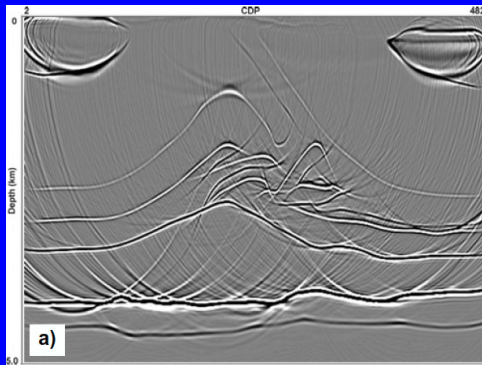
# Zero-Offset Raytrace Section

- Zero-offset section



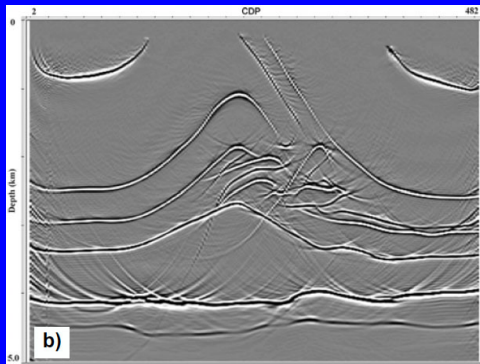
# Poststack Depth

- Kirchhoff poststack
- Initial model
- Poor Quality
- Bad raytrace amplitudes
- Poor quality raytracer
- Coarse sampling



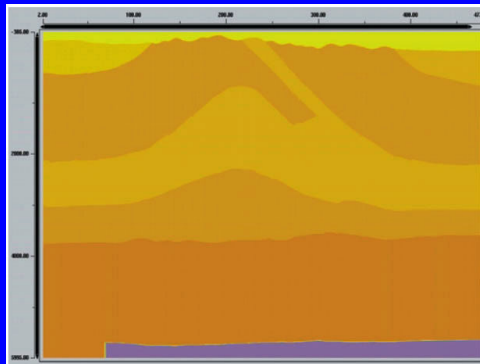
# Poststack Depth

- FX poststack
- Initial model
- Better Quality
- Bad raytrace amplitudes
- Poor quality raytracer
- Coarse sampling



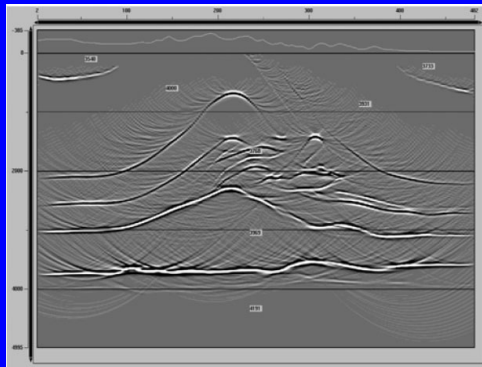
# New Macro Model

- Four iterations
- Time shift gathers
- Layer stripping
- Surface based
- Near surface detail
  - Refraction tomography
- From topography



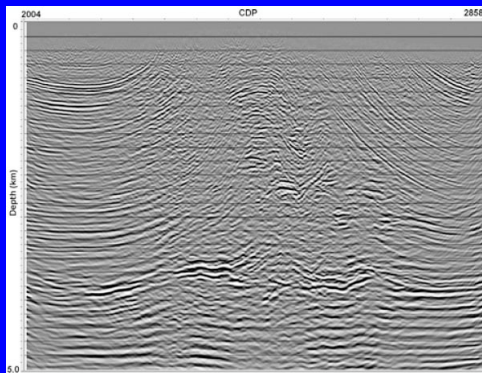
# Poststack Depth with Macro Model

- FX migration
- From topography
- Macro Model
- Best result?
  - Average velocities

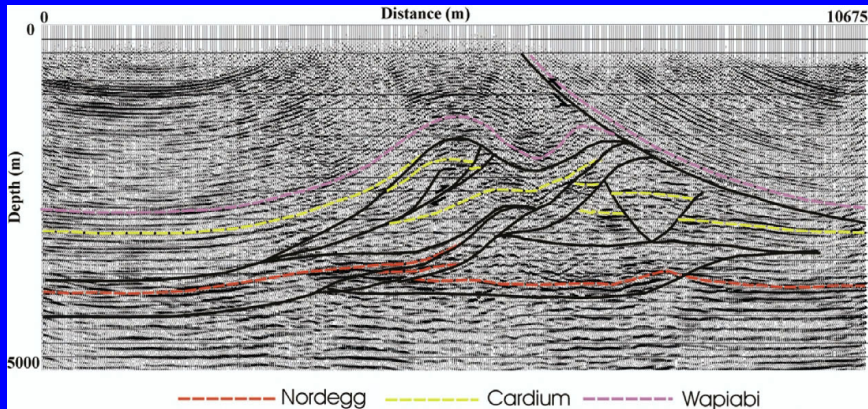


# Prestack Depth

- Final FX migration
- From topography
- Macro Model
- Improved image



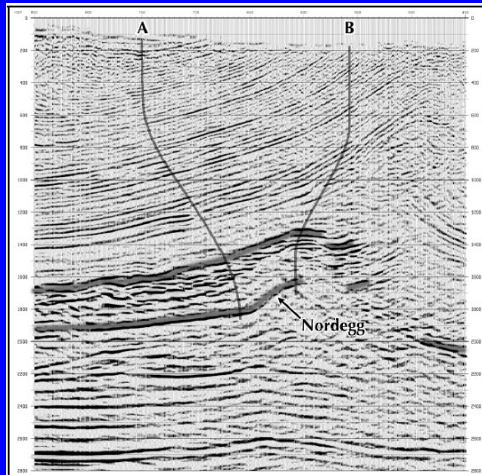
# Prestack Depth with Interpretation



Final Prestack FX depth migration using Macro Model with interpretation overlay.

# Isotropic PSTM

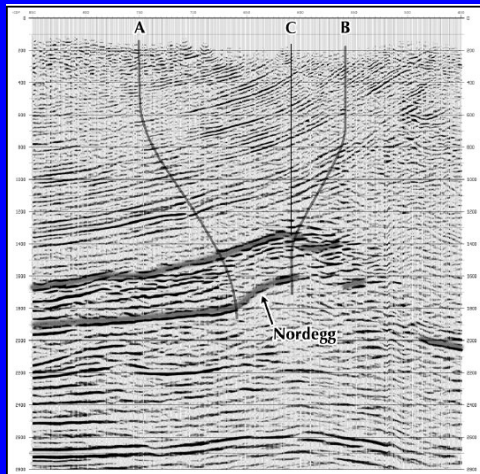
- Beginning PSTM
- Initial Well B
  - Nordegg objective
  - Well chosen on PSTM
- Objective missed





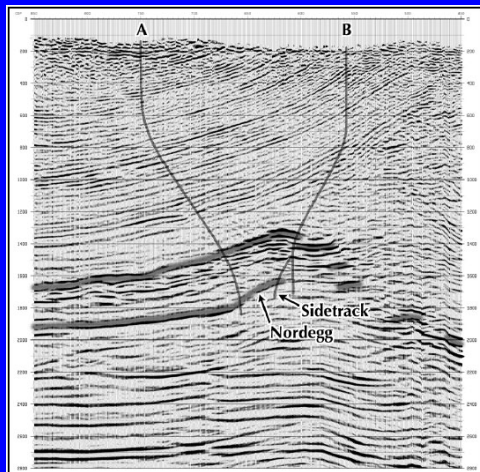
# Isotropic PSDM

- PSDM
  - Position not changed
- Objective improperly imaged



# Anisotropy PSDM

- $\delta$  negligible
- $\epsilon = .1$ 
  - $\epsilon$  scans - .025  $\rightarrow$  .3
- Objective shifted 250m (left)
- Side track successful



# Questions?