

Seismic Modeling, Migration and Velocity Inversion

Algorithmic Examples

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May 18, 2014

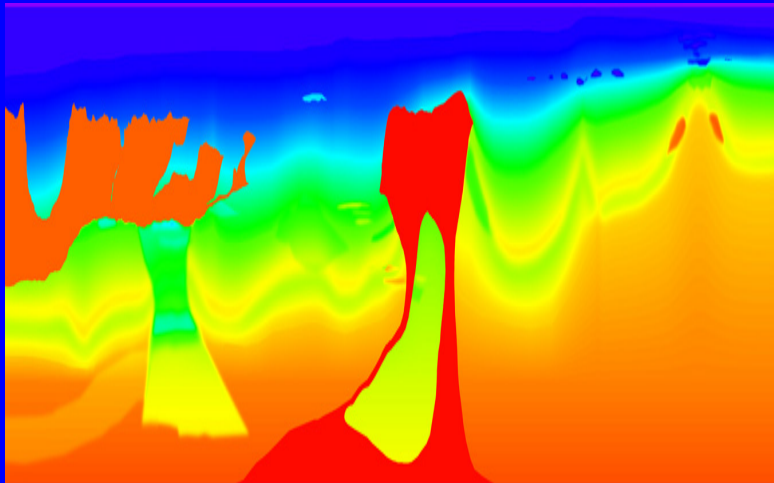
Outline

- 1 **BP 2004 Synthetic**
 - A little bit of VSP
- 2 **Simple Volcanics Model**
- 3 **Original Marmousi Synthetic**
- 4 **Southern China**
- 5 **MaGu Prospect**

Outline

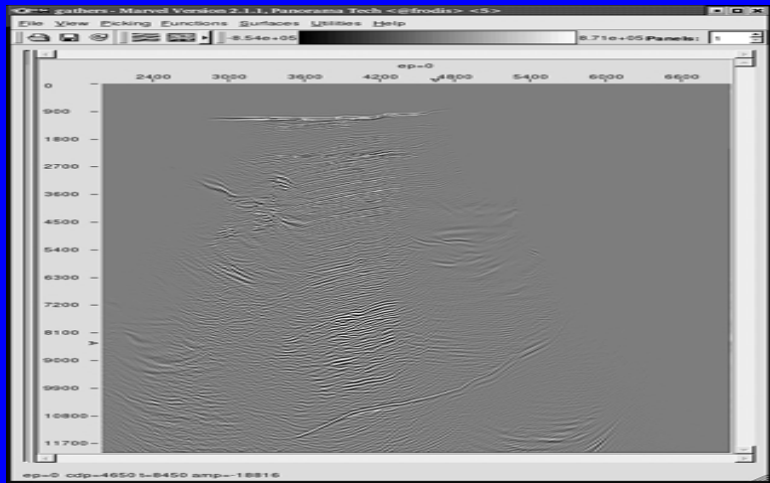
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BP 2004 Synthetic



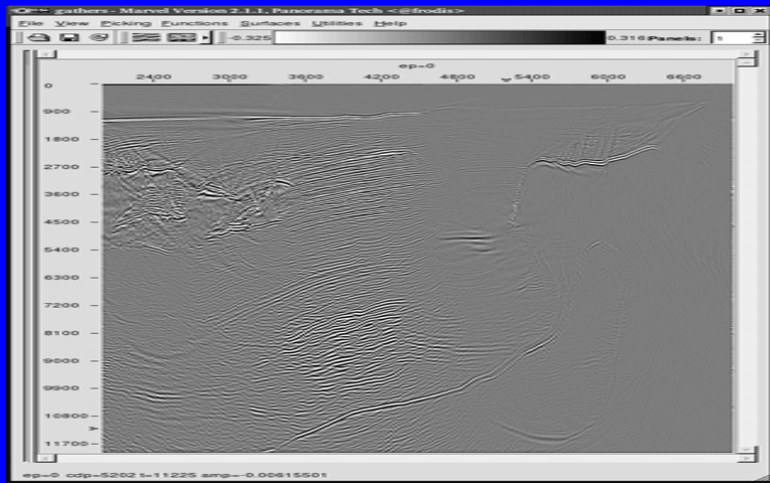
The BP2004 Model. After Billette *et al.* 2004.

BP2004 Synthetic



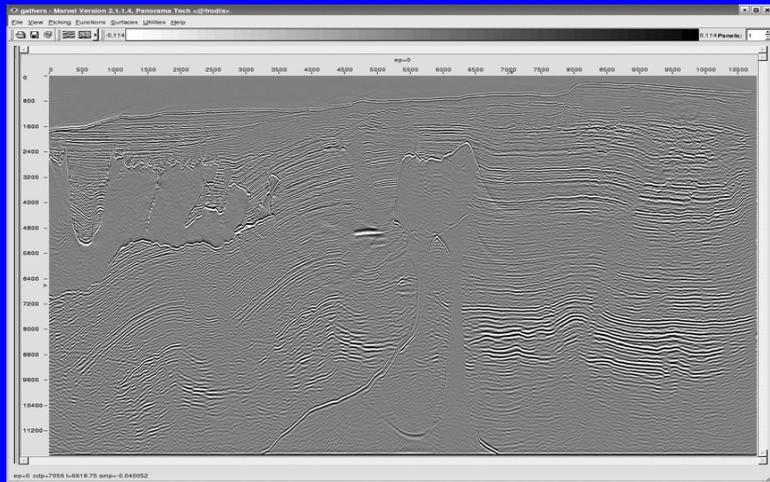
One-way on 30 percent of the available data.

BP2004 Synthetic



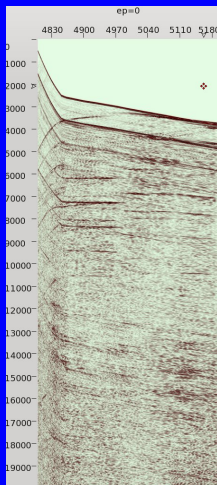
Two-way on 30 percent of the available data. More from the same input.

BP2004 Synthetic



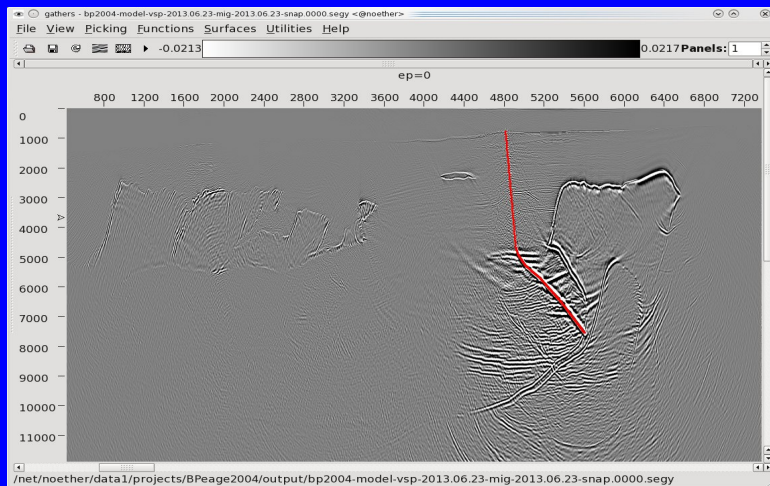
Full two-way on entire available input data.

VSP One Shot



Single shot into the BP2004 complex Gulf of Mexico Salt Model. Data and image courtesy of Panorama Technologies.

RTM VSP Migration

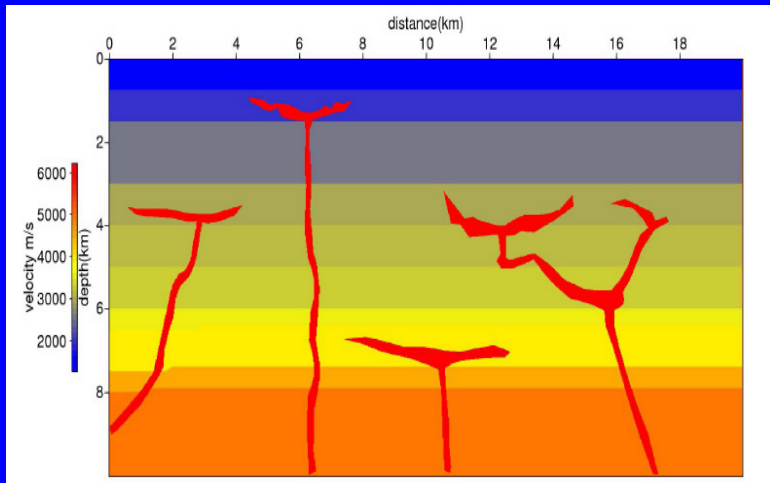


RTM migration of a VSP at the indicated location. BP 2004 complex Gulf of Mexico Salt Model. Data and image courtesy of Panorama Technologies.

Outline

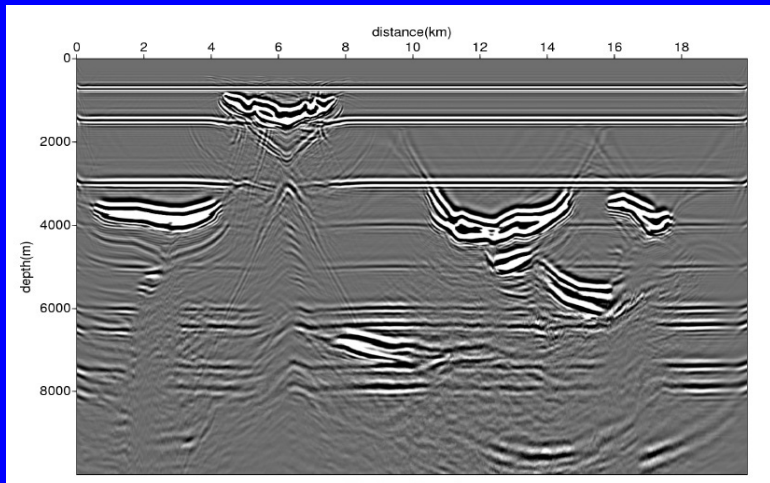
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Simple Volcanics Model



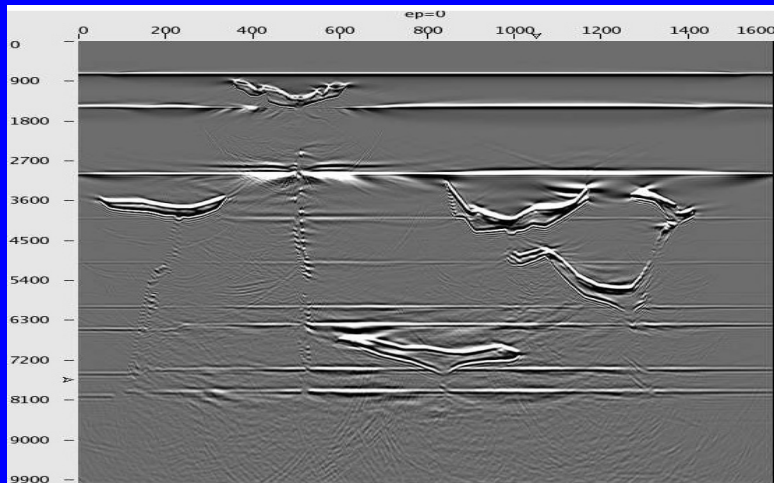
Volcanics Model of North Sea and Atlantic volcanic sills.

Simple Volcanics Model



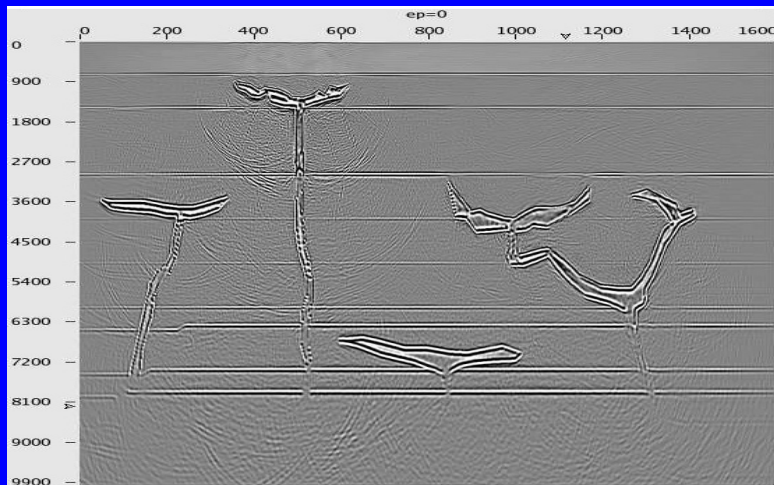
CWP-SU Kirchhoff of the Volcanics Model data.

Simple Volcanics Model



One-way WEM of the Volcanics Model data.

Simple Volcanics Model



Full two-way (RTM) of the Volcanics Model data.

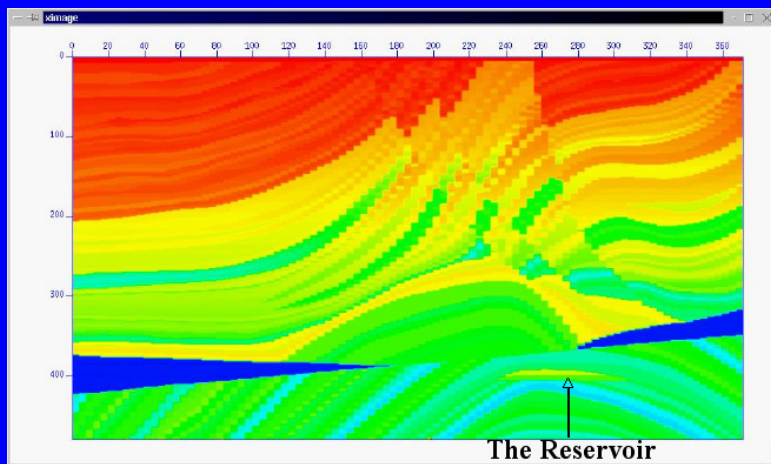
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The Marmousi Synthetic

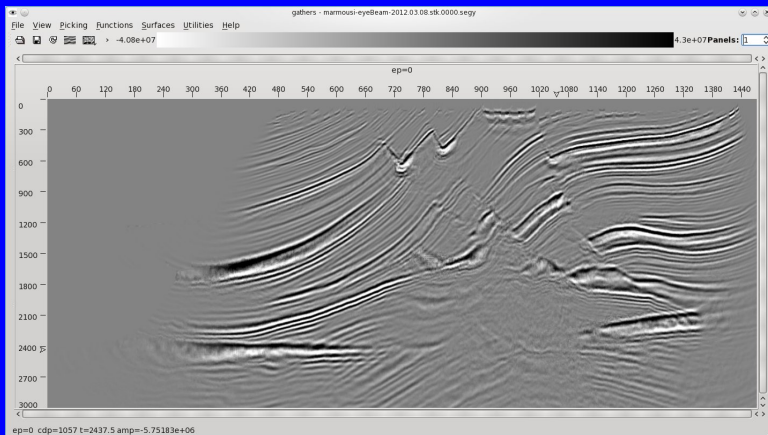
- Offshore Angola
- Acquired by Institute Francais de Petrol in 1989 or 1990
 - 3km depth by 9km line length
 - 240 Shots
 - Maximum offset 2600 meters
 - Maximum time 5 seconds
 - Data acquired at 6.25m
 - Sum to 96 channels at 25 meters
 - Marine single end spread
 - Full two-way-finite-difference propagation
 - See Roloff Versteeg's 1992 paper in Geophysics

Marmousi Model



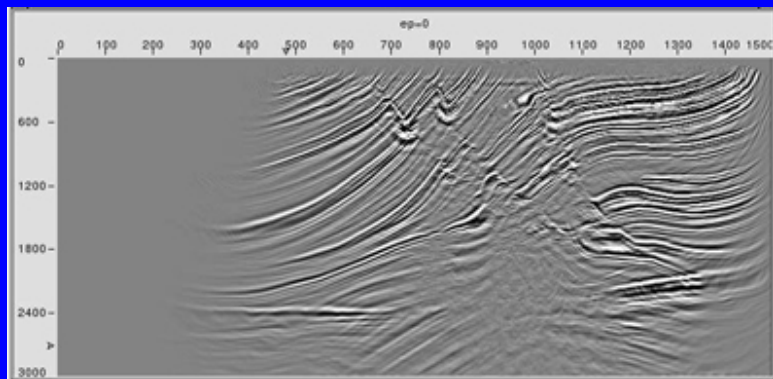
The Marmousi finite difference model grid.

Beam Migration



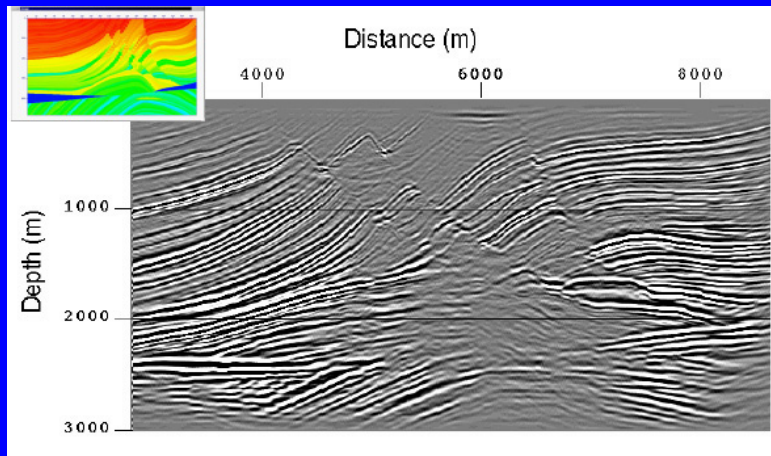
Multiple arrival Beam Migration of the Marmousi synthetic.

Kirchhoff Migration



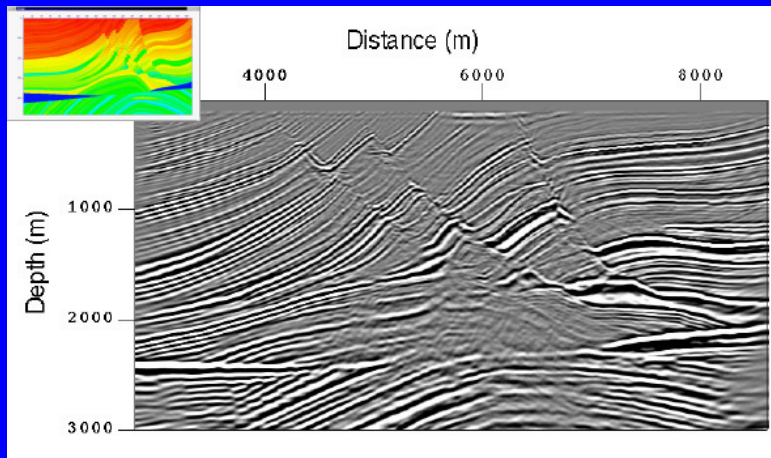
Single arrival Kirchhoff Migration of the Marmousi synthetic.

Multi-Arrival Kirchhoff Migration



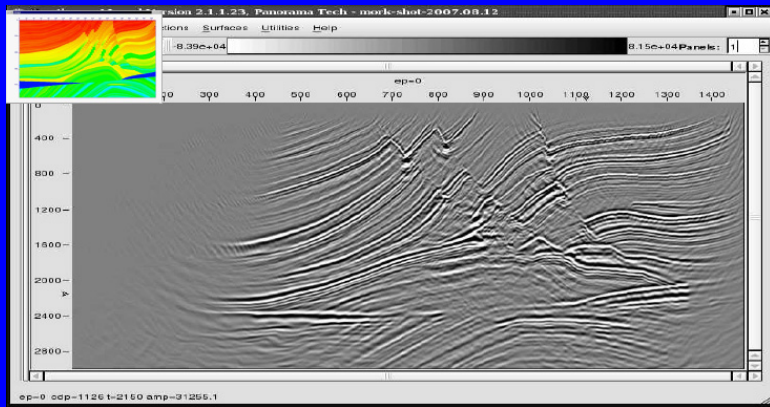
A multiple arrival Kirchhoff migration of the Marmousi synthetic. Courtesy Sam Gray CGG-Veritas.

Gaussian Beam Migration



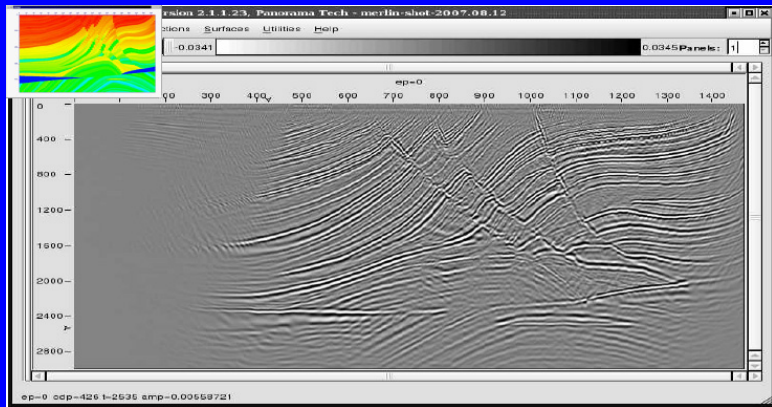
Gaussian Beam Migration of the Marmousi Synthetic. Courtesy Ross Hill, Chevron.

WEM (One-Way) Migration



A one-way phase screen migration of the Marmousi synthetic.

Reverse-Time (Two-way RTM) Migration



RTM of the Marmousi synthetic. Courtesy Panorama Technologies, Inc.

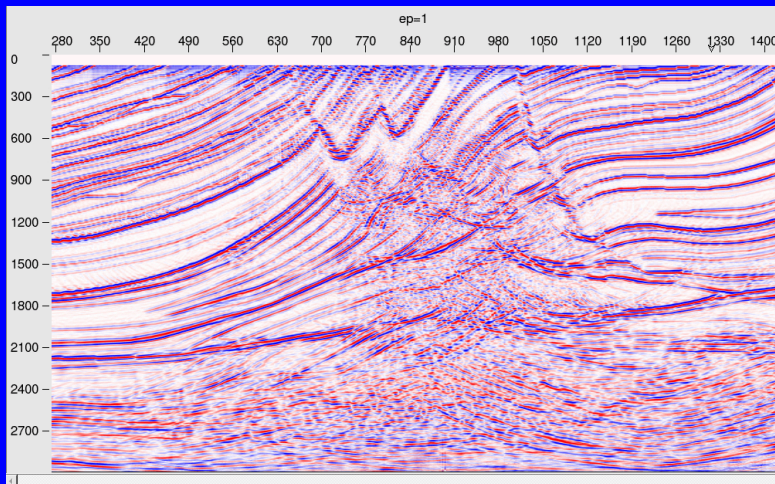
Remarks

- Image quality a function of algorithm accuracy
 - More accurate algorithms yield better results
 - Except in the case of simple Beam migration
- In increasing image quality order
 - Kirchhoff
 - Beam
 - Multiple-arrival Kirchhoff
 - Gaussian Beam
 - WEM
 - RTM

Marmousi Synthetic

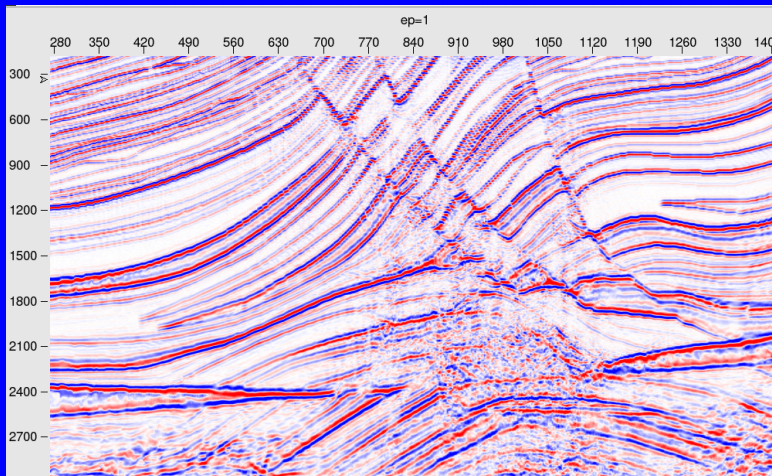
- Re-shoot by Panorama Technologies
 - Shots and receivers spaced at 25 meters
 - Maximum offset 9 km.
 - 360 receivers per shot
 - No receiver sum
 - Total recording time 7 seconds
 - Two-way propagation with high accuracy stencil

Kirchhoff PSTM Migration



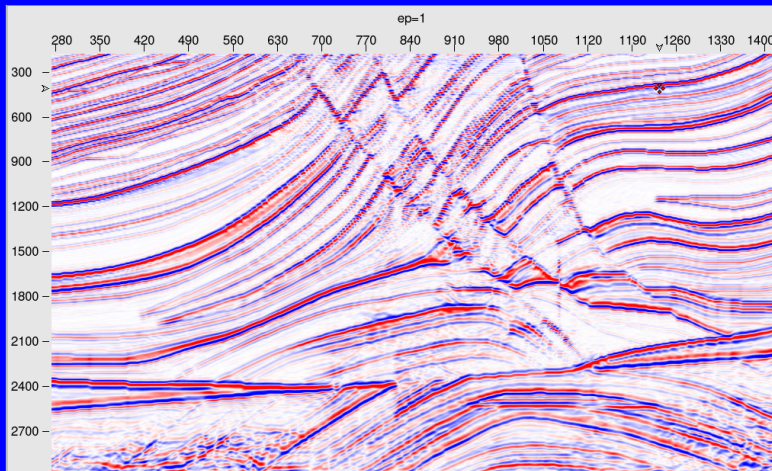
Prestack-time migration of the Marmousi Synthetic. Courtesy Panorama Technologies. 

Single Arrival Kirchhoff Migration



Prestack-single-arrival Kirchhoff migration of the Marmousi Synthetic.
Courtesy Panorama Technologies

WEM Migration



One-way phase-screen migration of the Marmousi synthetic. Courtesy
Panorama Technologies.

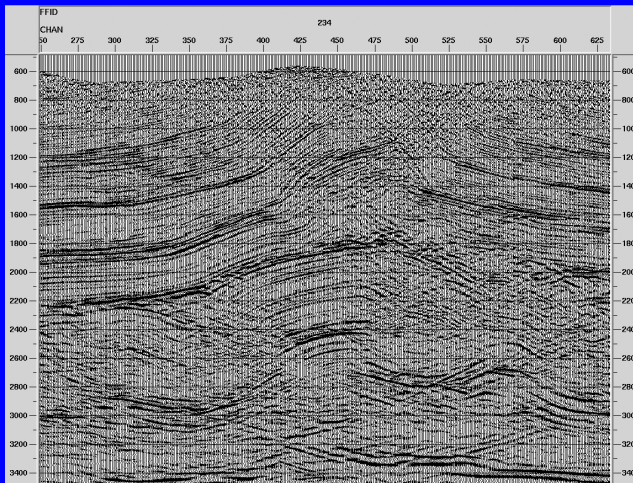
Remarks

- Algorithms sensitive to acquisition geometry
 - Point receivers improves overall results
 - No in field sum
 - Lower accuracy approximations produce decent results
 - Longer superior to shorter offset acquisition
 - Longer superior to shorter recording times
- Some sensitivity to algorithmic accuracy remains
 - But image quality improves overall
- Each algorithm produces acceptable result

Outline

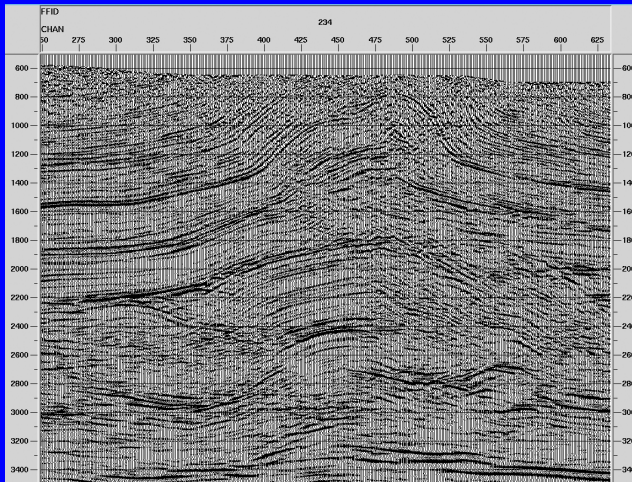
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Mountainous Area of Southern China



Curved ray Kirchhoff PSTM from Datum.

Mountainous Area of Southern China

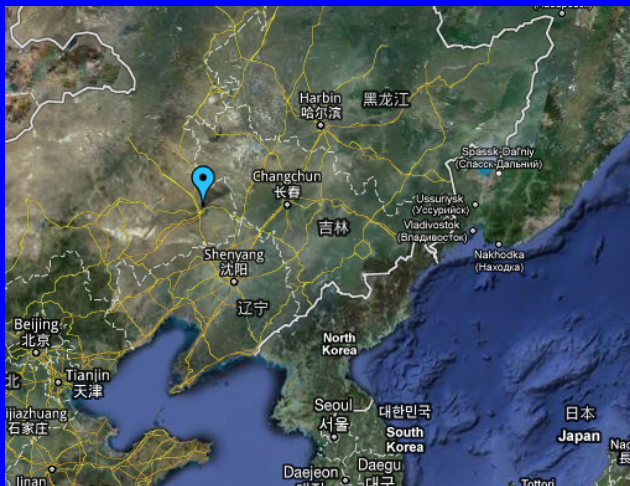


Curved ray Kirchhoff PSTM from topography.

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Laohe Location Map

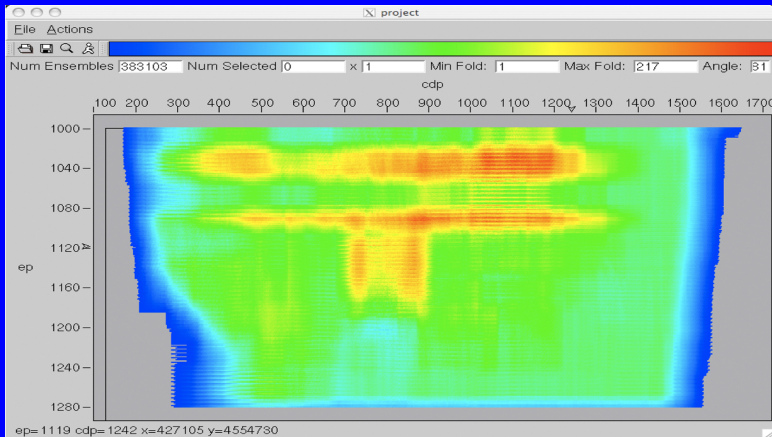


Located in the vicinity of Laohe China. At least its worked out of the exploration office there. Yellow line is Russian border.

Synopsis

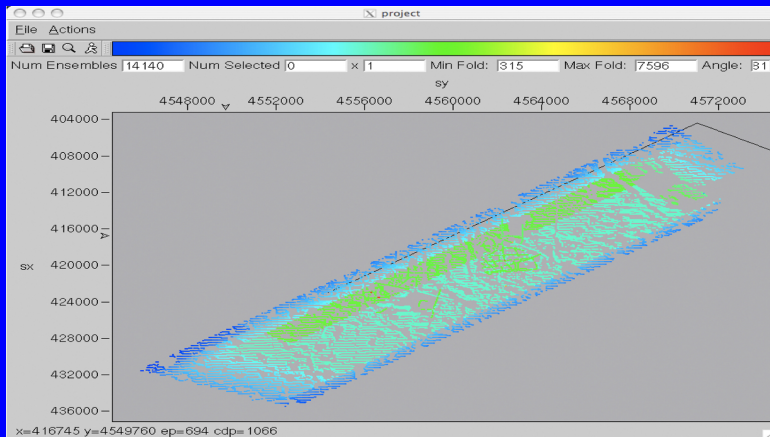
- QianShan Granitic Intrusion area
 - NE China near Russia border (Siberia)
 - Not too far from Harbin and the famous Ice Carving Festival
- Tertiary sediments between two granitic intrusions
- Almost a 2.5 dimensional structure
 - Prospect dips in crossline direction

Acquisition Fold



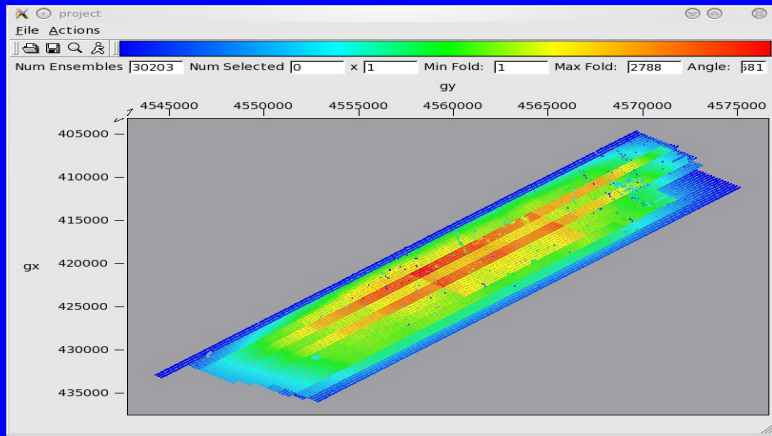
Magu fold map showing high fold coverage.

Shot Locations



Magu shot locations and receiver density. Note max of 7596 receivers/shot and narrow 3D coverage.

Receiver Locations

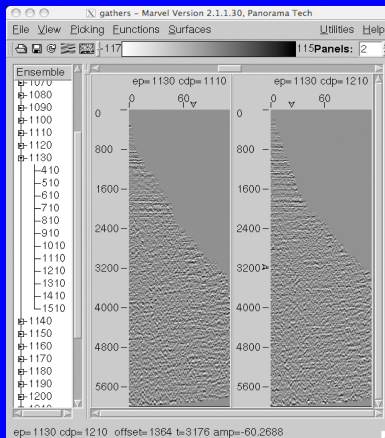


Magu receiver locations and shot density. Note max of 2788 shots/receiver and narrow 3D coverage.

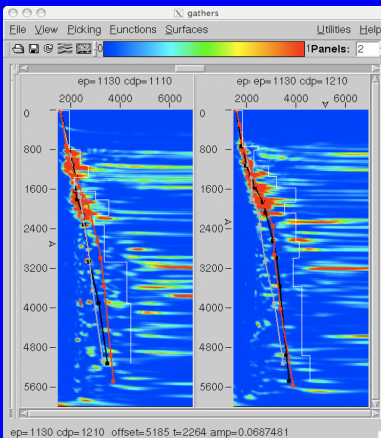
Preprocessing

- Preprocessing
 - Surface consistent deconvolution
 - Four term, source, receiver, offset, and CDP
 - Source/Receiver application
 - Bandpass filter 6-50 Hz
 - Long period automatic gain control
 - Three-dimensional spreading correction
 - For Kirchhoff and Beam only
 - Recover spreading decay
 - Imaging
 - Kirchhoff PSDM, PSTM,
 - Shot-Profile Merlin
 - Beam

Migration Velocity Analysis



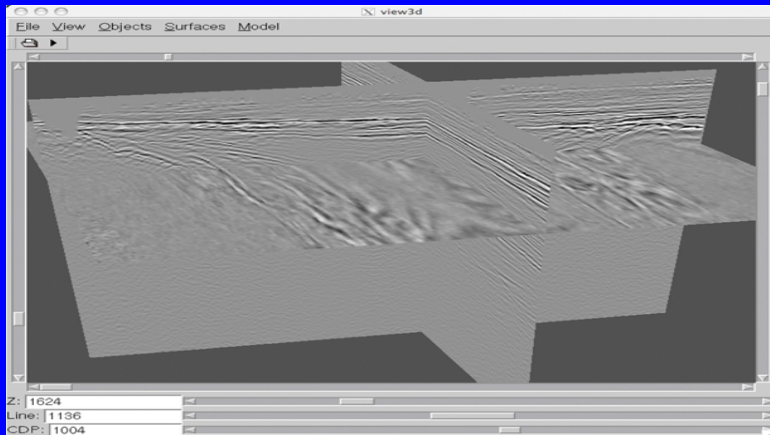
(a) Preprocessed CDP Gather



(b) Preprocessed CDP Semblance

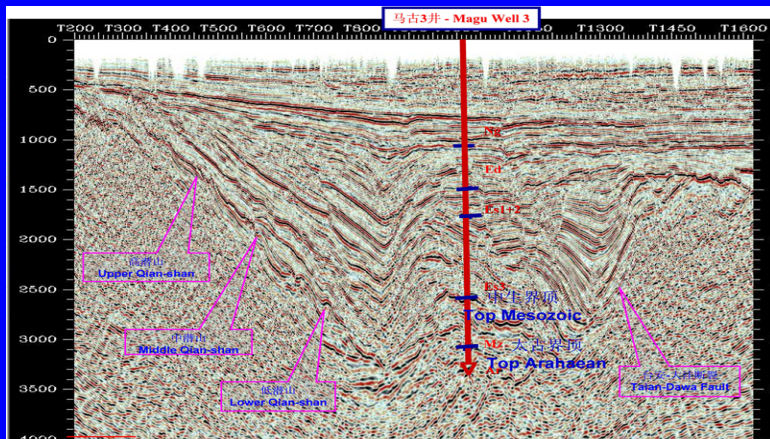
MaGu Preprocessed CDP and semblance.

Prospect Dimensionality



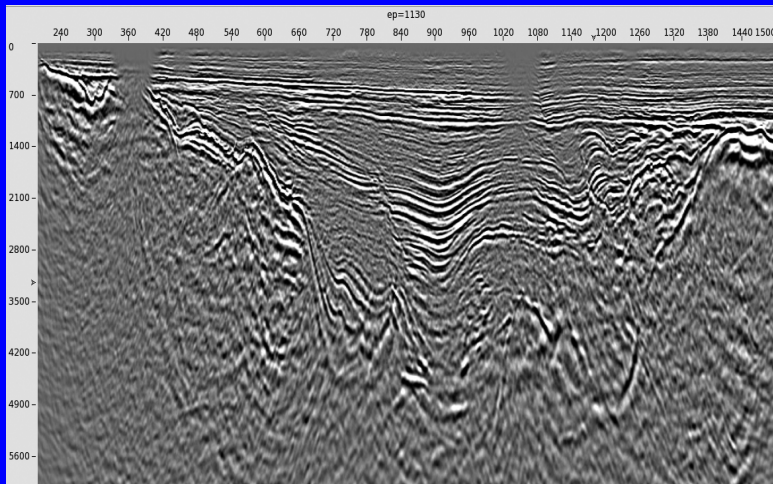
MaGu preprocessed stack appears to show that the geology is approximately 2.5 dimensional in nature.

PSTM Showing Geology

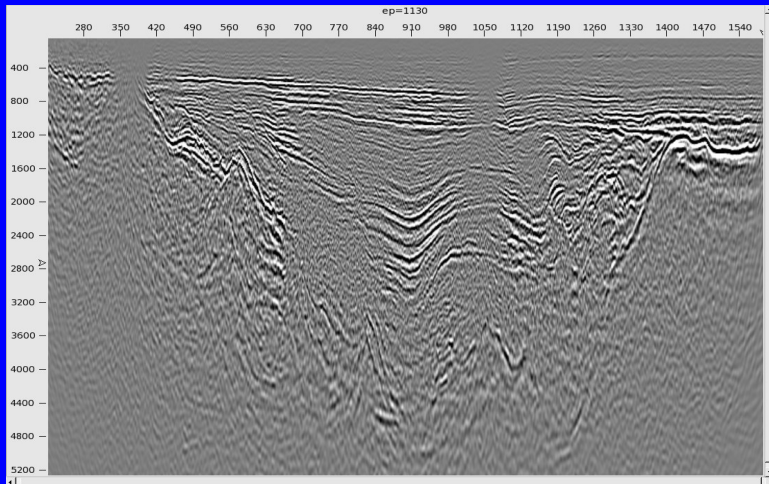


MaGu migration showing geology.

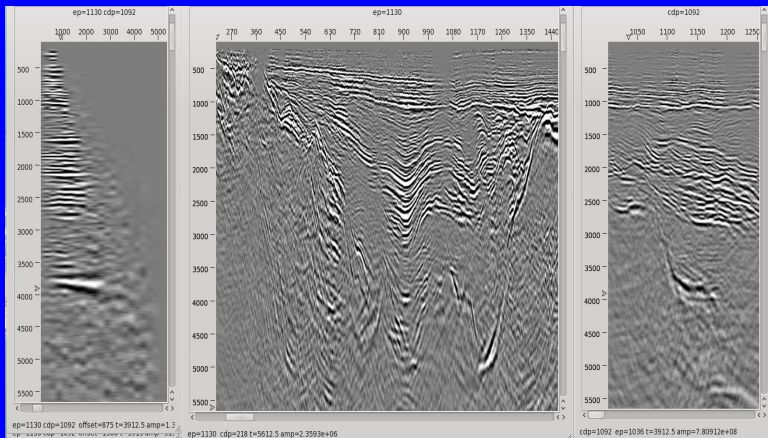
Kirchhoff Curved Ray PSTM - in Depth



Gaussian Beam in Depth

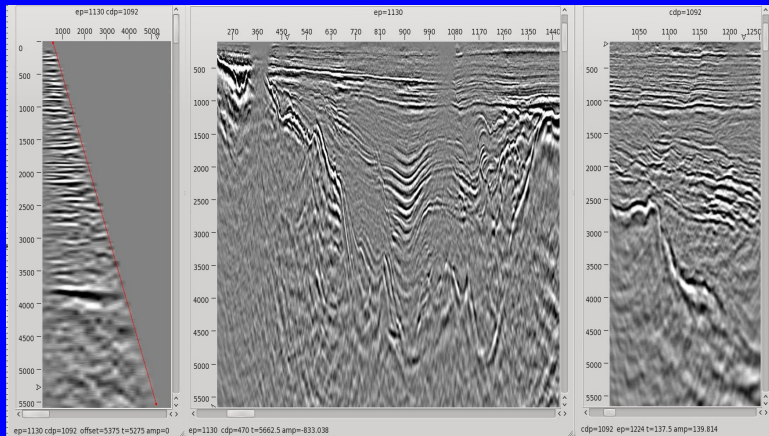


Beam Migration



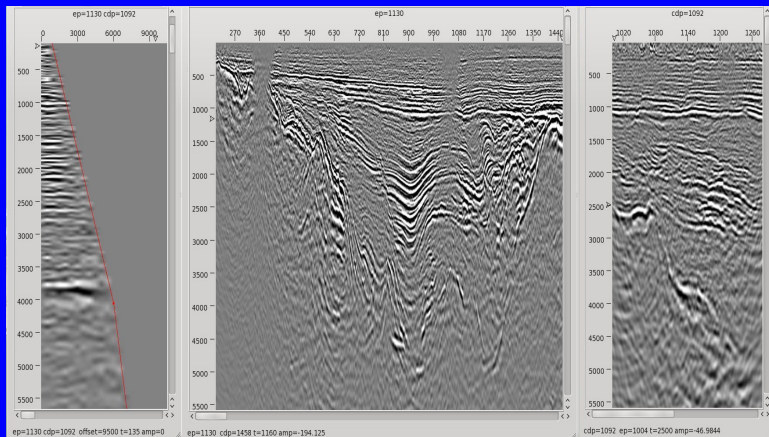
Beam migration of the MaGu Prospect data set. Courtesy Panorama Technologies.

Kirchhoff Migration



Kirchhoff migration of the MaGu Prospect data set. Courtesy Panorama Technologies.

RTM Migration



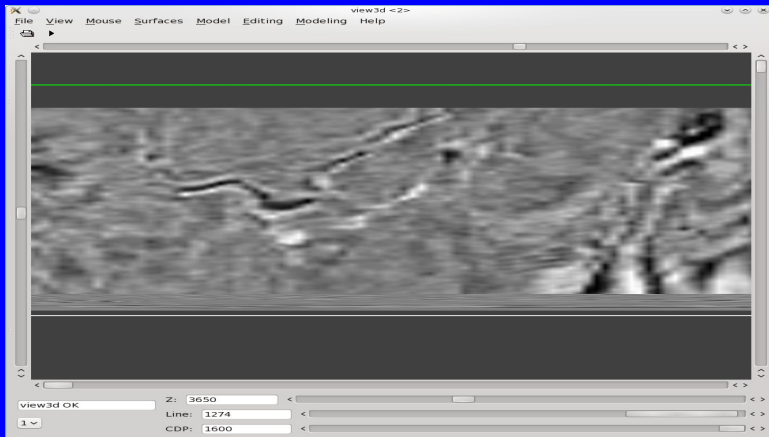
RTM migration of the MaGu Prospect data set. Courtesy Panorama Technologies.

Beam Migration



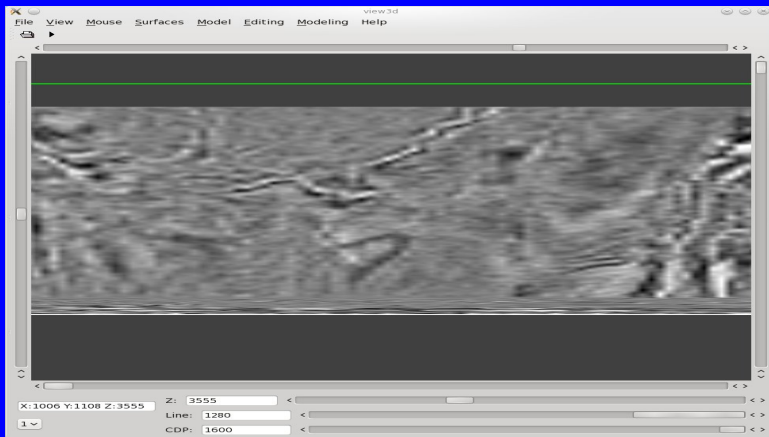
Beam migration of the MaGu Prospect data set. Courtesy Panorama Technologies.

Kirchhoff Migration



Kirchhoff migration of the MaGu Prospect data set. Courtesy Panorama Technologies.

RTM Migration



RTM migration of the MaGu Prospect data set. Courtesy Panorama Technologies.

Remarks

- Different quality
 - But all migrations delineated the prospect
 - Some significant differences between interpretations
 - RTM seems to have the greater detail
 - Beam seems to have least amount of background noise.

Questions?