Seismic Modeling, Migration and Velocity Inversion North Sea Dip-Directed Imaging

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May 18, 2014



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Outline

A Real Data Example

- Objective, Data, and Model
- Initial Migration
- Dip Analysis
- Dip-Directed Imaging
- Hess VTI DDI
- Real Data DDI
- Velocity Update
- Summary



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Objective

• Produce an interpretable image below a strong reflector at pprox 2.4 KM

Use existing velocity volume to perform a single pass beam migration

- Input data relatively small
- Large number of lines
- Small number of cross lines
- Target cross line in center

Hypothesis is that image should reveal strongly dipping section

The Data

North Sea

- Reasonable quality
- No Source/Receiver locations
 - Every trace is a shot
 - Every trace is a receiver
 - MVA/Tomography only
- Roughly 3km cables
- Approximately 80 fold
- Data fully regularized



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Initial Velocity Model

- Simple and smooth
- Three zones
 - Essentially water (blue)
 - Slight Speed up (Green)
 - Very Fast (Orange/Red)
- No apparent issue





Expectations

Expectations

- Interpretable structure
 - Below 2.4 km
- Strong dipping events
 - Based on pinchouts
 - Tectonically driven?
 - Compressional thrusting?
- Where's the dips
- Where's the coherency





Automatic Dip Analysis



(a) Sacked Volume

(b) Dip Volume

Assessing the potential for the existence of steep dips began with a review of an automatic dip analysis (in (b)) of the stacked volume shown in part (a) above. While the image in part (b) does appear to contain coherent dip energy at an apparent retrieves azimuth of 45 degrees, coherence is relatively weak.

Common Image Gathers (CIG)



High gain CIG's, particularly below the 2.5 km level, suggest that the velocity field is reasonable. Events below this level appear to be relatively flat. There is at least one event at approximately 3km that is not flat, but there is little reason to question the velocity field. So, where are the hypothesized dips?

Questions

• Why aren't dips apparent in the image?

- Image is accurate
- There are no dipping events.
- Blanked by multiples
- Weak reflectivity
- Focus on dip imaging
 - Dip Directed Imaging (DDI)
 - Perform multiple migrations with different dip ranges



How Many Dips

- Not Many
 - Side by side
- $\approx \pm 6$ ms/tr
- Multiples
 - Lower dip range
 - Extractable
- High Dip Noise
 - Smoothing





Full Beam Image



Single dip image of synthetic data from the HESS VTI model. Dip selected from ± 6 ms/tr range.

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Blanked Beam Image



A 0 to 6 ms/tr blanked image of the HESS VTI data set. A right hand view,

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Blanked Beam Image



A -6 to 0 ms/tr blanked image of the HESS VTI data set. A left hand view.

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Blanked Beam Image



A -3 to 3 ms/tr blanked image of the HESS VTI data set. Dips outside ±3 only transferred to the HESS VTI data set.

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-1 to 1 ms/tr Dip Exclusion



(a) ± 1 ms/tr Exclusion

(b) ±1 ms/tr Inclusion

Two images of the real data. In (a) we see the result of using dips outside the range ± 1 ms/tr. The (b) panel shows an image using only dips within the ± 1 ms/tr range. Clearly there are some dipping events in the original data. Why weren't they immediately visible in the initial migration?

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CDP Comparisons



(a) Full Beam High Gain CIG

(b) \pm 1 ms/tr Exclusion CIG

Direct comparison of highly-gained-full-beam CDP gathers with dip directed gathers suggest that the velocity model may be the culprit.

Line Direction

Interestingly, dip coherency in the line direction supports the validity of the imaged dips fairly strongly. The key point is the significantly smaller difference between the original and the DDI images. Reasons may be:

- Smaller Aperture
 - Lower dips
- Smaller xLine Spacing
 - Less Aliasing



Depth Slice Comparisons



(a) ± 1 ms/tr Inclusion

(b) ± 1 ms/tr Exclusion

When carefully compared, depth slices from the ± 1 images reveal dramatic differences. The exclusion slice in (b) shows considerable coherence at an apparent angle of approximately 45 degrees. The inclusion slice in (a) shows a weak correlation with the slice in (b) and thus provides some support to the validity of the dips in the ± 1 Exclusion image.

A Quick Summary

Steep Dips

- Somewhat realistic
- Supports dipping event hypothesis
- Image difficult to interpret
 - Poor correlations
- Interpretation difficulties
 - Data not recorded properly
 - Short (3 km) offsets
 - Loss of source/receiver information
 - Data volume too small
 - Large number of lines
 - Small number of cross lines
 - Poor velocity



Multiples

Original time CDP's

- Evidence for multiples
- Residual moveout
- Strong semblance



Multiples

Original time CDP's

- Evidence for multiples
- Residual moveout
- Strong semblance



Horizon Based Merge



(a) Horizon Based Blend

(b) ± 1 Inclusion

A blend of the two image after a full blanking above and below a picked horizon.

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Horizon Based Merge

Initial Migration Merge

- Weak multiple semblance
- Demonstration of faster velocity



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Updated Velocity

- Three Updates
 MVA
- Tomography
 - Very small benefit



Initial Velocity

- Three Updates
 MVA
- Tomography
 - Very small benefit



Third Update CIG



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Third Update Images



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Third Update Images



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Summary

- Easier to interpret
- Greater coherency
- Dip Directed Imaging
 - Provided the clue
 - Not necessary for final image
- Fast Beam migration essential



Questions?

