A new method for dip estimation based on seismic waveform curvature/flexure analysis

Haibin Di, and Ghassan AlRegib
Center for Energy & Geo Processing (CeGP)
Georgia Institute of Technology
{hdi7, alregib}@gatech.edu
September 25, 2017
Outline

• Motivation
• Waveform curvature/flexure
• Algorithm description
• Result analysis
• Application
• Conclusions
Motivation

• Dip estimation is a routine process in interpreting seismic data
• Many dip algorithms available:
  • Complex seismic trace analysis (instantaneous phase) (Barnes, 1996, 2007)
  • Gradient structure tensor (Hoecker and Fehmers, 2002)
  • Discrete scanning (Marfurt et al., 1998)
  • Hybrid (Aqrawi and Boe, 2012)
  • and more
• Waveform curvature/flexure analysis offers a new approach
• How is its performance?
Waveform curvature/flexure

Definition:

Curvature/flexure analysis of seismic waveforms in a vertical section.

<table>
<thead>
<tr>
<th>Information for analysis</th>
<th>Waveform curvature/flexure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflection waveform</td>
<td>Vertical (the x-z and/or y-z plane)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Computation direction</th>
<th>Waveform analysis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>a. Resolution enhancement</td>
</tr>
<tr>
<td>(the x-z and/or y-z plane)</td>
<td>b. Dip estimation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interpretational applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Resolution enhancement</td>
</tr>
<tr>
<td>b. Dip estimation</td>
</tr>
<tr>
<td>c. Reflector decomposition</td>
</tr>
</tbody>
</table>

Check “3D curvature analysis of seismic waveform & its interpretational implications”, if you missed my first presentation
How does it work?

Waveform curvature

Waveform flexure
Why noisy?

Peaks: maximum bending vs. no bending

Zero-crossings: no bending vs. no bending

Troughs: maximum bending vs. no bending
Algorithm

Quadrature waveform helps enhance the computation at non-peak/trough samples.
Result

Waveform curvature

Real waveform only

Complex waveform

Waveform flexure
Comparison:

Discrete scanning

Complex seismic-trace analysis

Waveform curvature

Waveform flexure

Dip overestimate
Comparison: Dip-guided horizon tracking

Magenta: Waveform curvature; Green: discrete scanning; Black: complex seismic-trace analysis
Applications

• Horizon tracking
• Geometric attribute analysis
Application #1:

Horizon tracking of 4 peaks and 4 troughs

Waveform curvature

Waveform flexure
Application #2:
Dip-guided multi-trace attribute analysis

- Dip & azimuth
- Curvature & azimuth
- Flexure & azimuth
- Fault imaging

Time slice
Conclusions

• Curvature/flexure analysis offers a new approach for dip estimation;
• An integration with complex seismic trace analysis is necessary;
• Good accuracy and computational efficiency;
• More work is in need for better noise robustness
More information (e.g., recent research, publications, tools, and codes) is available by:

- Visit our SEG booth: #2109
- Visit our center: http://www.ghassanalregib.com
- Visit my webpage: https://haibindi.wixsite.com/home
• Backup slides
Application #1:

horizon tracking & modeling

Horizon set

Horizon modeling