WHY SHOULD WE PAY FOR A MERGED SURVEY THAT CONTAINS THE DATA WE ALREADY HAVE? AN OKLAHOMA REDFORK EXAMPLE

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ABSTRACT

The Red Fork Formation of the Anadarko Basin has been extensively explored and produced, and was a target for early 3D seismic acquisition programs in the 1990s. Significant resources remain, such that many of these legacy surveys have been reprocessed and merged by commercial seismic processing companies to provide more regional coverage. Merging multiple seismic data volumes prior to migration increases the migration aperture and hence the lateral resolution of faults, channel edges, and steeply dipping reflectors that were previously unimaged along the edges of the original surveys.

We use modern seismic attributes to show that in addition to providing a more complete image of a Red Fork incised valley system, that a reprocessed “mega-merge” survey covering the study area reduces footprint contamination and improves both vertical and lateral resolution. Most-positive and most-negative curvature, coherence, Sobel filter similarity, and spectral decomposition within the context of seismic geomorphology delineates architectural elements within the Red Fork incised valleys that are not readily apparent on the seismic amplitude data. In addition to improved illumination of the five previously identified stages, the mega-merge data illuminates a previously unreported sixth stage.

Introduction

Since its introduction in the 1980s, 3D seismic surveys blanket more and more of Midcontinent of the USA and are not only used by geophysicists at large oil companies but also by geologists and engineers in small partnerships. Many of these non-geophysical seismic interpreters are unfamiliar with concepts of migration aperture and recent advances in seismic processing. Interpreters with a better understanding of seismic technology still need to justify the purchase of merged, reprocessed data to their business colleagues. In this paper, we provide a case study illustrating the value or a megamerge survey through improved attribute images of an incised valley system.

The study area is located in the Anadarko Basin in west central Oklahoma. The formation of interest is the Middle Pennsylvanian age Red Fork Formation. Figure 2 shows the location map of the specific study area used in this project.

Clement (1991) describes the Red Fork valley system as having three stages of deposition. Stage I consists of basal lag structures and low sinuosity channels with very low width/depth ratio, moderate relief on the basal scour surface and steep banks. This stage eroded part of the Middle and Lower members of the Red Fork (Figure 2a). Stage II is characteristic of laterally variable, confined meander belt sequences, which gave rise to amalgamated point bar, clay plug and overbank deposits. The meander belts have a moderate width/depth ratio and moderate to high relief on basal scour surfaces (Figure 2b). Stage III is charaterized by active downcutting channels through poorly consolidated older valley fill. The channels have a low width/depth ratio and exhibit similar characteristics to Stage I. The sand found in this stage is reworked and redistributed by marine-tidal processes during transgression (Figure 2c).

Davogusto et al. (2012) compared well logs a suite of well logs that fall within the megamerge survey in this paper and found that Stage I and IV are invisible on the seismic data.
This paper will show the value of the megamerge in improving the images of Stages II, III, and V.

Figure 1. Block diagram illustrating the evolution of the Red Fork valley system by stages. (a) Stage I, (b) Stage II and (c) Stage III (After Clement, 1991). Stages defined in this project are represented in the model by red.

Impact of reprocessing merged surveys on poststack seismic interpretation

The Watonga survey (magenta polygon in Figure 3) was acquired by Amoco in three stages (1993, 1994 and 1996) with the main objective of imaging the Red Fork interval within the Anadarko Basin. The Watonga survey is of particular interest because it served as the first published application of 3D spectral decomposition analysis (Peyton et al., 1998). Chesapeake Energy bought the Amoco property and associated seismic data in the late 1990s. In 2009, Chesapeake and several other companies licensed five 3D surveys to CGGVeritas to form a “mega-merge” survey (blue polygon in Figure 3). Missing areas were shot to form more continuous coverage. To further facilitate the geologic interpretation of this area, these newly acquired and legacy pre-stack volumes were then reprocessed together with newer technology including the noise attenuation, tomographic reference static, and migration algorithms shown in Table 1, such that one survey helps image adjacent areas in previously separately processed, but adjoining surveys.
Table 2 summarizes the survey geometry of the reprocessed mega merged survey and the legacy survey.

<table>
<thead>
<tr>
<th>2006 Processing sequence applied to the mega merged survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demultiplex/reformat (3D geometry and manual trace edits):</td>
</tr>
<tr>
<td>Geometry QC: Binned 110ft by 110ft</td>
</tr>
</tbody>
</table>
Table 1. Processing parameters used to merge all seismic surveys.

<table>
<thead>
<tr>
<th>Processing Parameter</th>
<th>Mega merged survey</th>
<th>Watonga survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spreading gain recovery type</td>
<td>T^2 (Phase Matching)</td>
<td></td>
</tr>
<tr>
<td>Noise burst attenuation</td>
<td>(not on Watonga surveys)</td>
<td></td>
</tr>
<tr>
<td>Surface consistent deconvolution</td>
<td>Operator length 160 ms, prewhitening= 10%</td>
<td></td>
</tr>
<tr>
<td>Surface consistent gain:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spiking Deconvolution</td>
<td>Operator length=160 ms.</td>
<td></td>
</tr>
<tr>
<td>Consistency Scaling</td>
<td>Line/Shot/Receiver terms</td>
<td></td>
</tr>
<tr>
<td>Tomographic refraction statics</td>
<td>(Datum: 1900 ft. Offset 0-10000 ft, replacement velocity=8500ft/s)</td>
<td></td>
</tr>
<tr>
<td>Velocity analysis, phase matching, surface consistent residual statics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity analysis, noise burst attenuation, spectral whitening 4/8-115/130 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase matching, surface consistent residual statics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FX Noise attenuation – shot domain, velocity analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface consistent gains, CDP Trim statics, 1500 ms pre-stack gain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-stack time migrated Flexi-binning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-stack time migrated velocity analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-stack Kirchhoff time migration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual velocity analysis, NMO, mute application and tomographic long wavelength</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Acquisition geometry of mega and legacy surveys

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mega merged survey</th>
<th>Watonga survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bin size</td>
<td>110ft*110ft</td>
<td>82.5ft*82.5ft</td>
</tr>
<tr>
<td>Inline direction</td>
<td>N-S</td>
<td>W-E</td>
</tr>
<tr>
<td>Crossline direction</td>
<td>W-E</td>
<td>N-S</td>
</tr>
<tr>
<td>Total number of inlines</td>
<td>872</td>
<td>886</td>
</tr>
<tr>
<td>Total number of crosslines</td>
<td>721</td>
<td>923</td>
</tr>
<tr>
<td>Seismic area</td>
<td>244.6 mi^2</td>
<td>136 mi^2</td>
</tr>
</tbody>
</table>

Comparing the amplitude spectrum computed from the Oswego to the Novi horizons, we observe that the mega merged survey is better balanced than the legacy survey in the zone of interest (Figure 4), which will provide better vertical resolution of the geological features.
The five legacy and infill surveys have different ranges of offsets, with more modern surveys having wider azimuths, longer offsets and greater fold. CGGVeritas reprocessed the data using pre-stack time migration and one seismic survey as reference. Examination of Figure 5 shows a lack of far offsets in the area of the 1993-1996 Watonga survey. In Figure 5, we plot a horizon slice along the top Oswego through different ranges of offset data volumes (0-5000 ft., 5000-8000 ft., 8000-11000 ft., 11000-14000 ft. and 14000-17100 ft.). Note that the data quality is good for all areas up to approximately 11000 ft. offset. Beyond this offset, the images in the Watonga survey contain only migration operator artifacts from the neighboring surveys acquired with larger offsets. This offset limitation will reduce the incidence angle used in any inversion analysis.

Processing sequences are applied soon after the data are acquired. For legacy surveys, these processing parameters may have been lost. In particular, the original sweep applied at the time of acquisition must be considered while reprocessing the old seismic data.

Figure 7 through 9 show the enhancement of the data quality by reprocessing with newer technology. Note the reduction of migration artifacts, improvement of channel imaging, and acquisition footprint removal in the “mega merged” survey compared to the original Watonga survey.
Figure 5. Representative gathers and base map indicating their location. Note that location A and D have good amplitude while B and C have low amplitude for far offsets. It appears that the maximum useable offset is about 10000 ft. for B and 12000 ft. for D. The small residual amplitudes beyond these ranges are due to migration ellipses from the longer offset surveys.
Figure 6. Horizon slice along the Oswego surface through offset-limited stacked amplitude volumes: (a) 0-5000 ft. (b) 5000-8000 ft. (c) 8000-11000 ft. (d) 11000-14000 ft. and (e) 14000-17100 ft. The Oswego Lime was interpreted as a strong peak along the seismic volume. Residual moveout (Figure 5) results in zero crossing and troughs at far offsets. Note how the amplitude approaches zero in the NE corner of the “mega-merged” survey for (e) 14000-17100 ft. offset. The circular areas in e) shows the farthest reach of the migration aperture from adjacent surveys.
Figure 7. North-South vertical section through the Watonga survey. Blue arrows indicate channels and yellow arrows migration and other noise artifacts.
Figure 8. North-South vertical section through the “mega merged” survey. Blue arrows indicate channels and yellow arrows migration and other noise artifacts.
Figure 9. East-West vertical section across the Watonga survey. Blue arrows indicate channels and yellow arrows migration and other noise artifacts.
Figure 10. East-West vertical section across the “mega merged” survey. Blue arrows indicate channels, yellow arrow migration and other noise artifacts, and orange indicate possible faults highlighted with red punted lines.
Attribute sensitivity to reprocessing.

3D seismic attributes enable the interpreter to better visualize subtle subsurface geological structures. In the Red Fork interval, channel patterns can be delineated using edge- and facies-sensitive attributes such as coherence, Sobel filter similarity and most positive and most negative curvature. Lateral changes in amplitude and thickness can be mapped using spectral component attributes.

Acquisition footprint as well as other seismic artifacts are present in the Watonga survey, severely contaminating seismic attributes such as curvature. Reprocessing and merging adjacent legacy surveys, supresses footprint, better delineating previously hidden geologic features that were previously ignored.

The simplest and perhaps most important attribute is the time structure of the geologic formation of interest (Figures 11 and 12). Footprint is noticeable in the Pink Lime and deeper horizons.

Figure 11. Time structural map of the top Pink Lime. Note how layers dip to the SW.
Coherence

Coherence attributes are useful in delineating channel edges when those channels are thick enough to cause measurable changes in the form of the wavelet (Chopra and Marfurt, 2010). We use energy-ratio similarity volumes (the ratio of the energy of the Karhunen-Loeve filtered data over the energy of the original unfiltered data) to illustrate the impact of reprocessing (Figures 13 and 14).

Figure 12. Time structural map of the base of the channels in the Red Fork. Note how layers dip to the SW. This horizon was interpreted at the base of the most visible channels. Note the incised channel indicated by the white arrows.
Figure 13. Phantom horizon slice 12 ms below the Pink Lime through the energy ratio similarity (coherence) volume computed from the 1993-1996 vintage Watonga survey. Yellow arrows indicate incised channels. Orange arrows indicate NS-EW footprint. C-C’ and D-D’ vertical sections illustrate the valley fill in the Red Fork Formation.
Figure 14. Phantom horizon slice 12 ms below the Pink Lime through the energy ratio-similarity (coherence) volume computed from the mega merged survey. Yellow arrows indicate incised channels. Notice the reduction on the footprint. C-C', D-D', and E-E' vertical sections through the main valley fill in the Red Fork Formation.
Sobel filter similarity measures lateral changes in amplitude rather than the lateral changes in the waveform (Chopra and Marfurt, 2010). Depending on the geology and data quality, Sobel filter similarity may delineate subtle edges not seen by energy ratio similarity, particularly for features below one fourth (¼) wavelength resolution where the waveform does not change significantly. Figures 15 and 16 show a phantom slice horizon through the Sobel filter similarity volumes. The greater acquisition footprint is due to lack of careful amplitude balancing in the original processing.
Figure 15. Phantom horizon slice 12 ms below the Pink Lime through the Sobel filter similarity volume computed from the 1993-1996 vintage Watonga survey. Yellow arrows indicate incised channels. Orange arrows indicate the strong NS-EW footprint patterns. C-C’ and D-D’ vertical sections illustrate the valley fill in the Red Fork Formation.
Figure 16. Phantom horizon slice 12 ms below the Pink Lime through the Sobel filter similarity volume computed from the mega merged survey. Yellow arrows indicate incised channels. Notice the reduction on the footprint. C-C', D-D', and E-E' vertical sections through the main valley fill in the Red Fork Formation.
Curvature

Curvature is defined by Chopra and Marfurt (2007) as the inverse of the radius of a circle tangent to a two-dimensional curve in a particular point (Figure 17). Structural curvature attributes measure bending and folding as well as sedimentological processes such as levees and differential compaction of incised valleys.

![Diagram of Curvature](image)

Figure 17. 2D curvature (K) of a two-dimensional line defined. Anticlinal features have positive curvature, synclinal features have negative curvature and planar features (horizontal or dipping) have zero curvature (After Roberts, 2001).

When extracting structural curvature attributes through the Red Fork Formation, two main curvature responses can be interpreted over the channels features. For narrow channels, we observe high most-positive curvature on the edges and high most-negative curvature values along the channel axis or thalweg (Figure 18a). For wide channels, we observe high most-positive curvature on the edges and high most-negative curvature values on the channel base edges and zero curvature on the bottom channel plane (Figure 18b).
Figure 18. Curvature response of the Red Fork Formation channels under the Pink Lime Formation. a) Narrow channels are expected to have high most-positive curvature on the edges and high most-negative curvature values on the channel’s thalweg. b) Wide channels are expected to have high most-positive curvature on the edges and high most-negative curvature values on the channel base edges and zero curvature on the thalweg plane. Both may give rise to differential compaction anomalies in overlying sediments.
Figures 16 through 19 show a representative phantom horizon slice through the most positive curvature and most negative curvature. Figures 20-24 show the most positive curvature and most negative curvature co-rendered with Sobel filter similarity to enhance the channels edges. Note how the curvature attributes over the 1993-1996 vintage Watonga survey are less detailed than over the newer mega-merge survey. The channel associated with the Red Fork Formation are better delineated by the attributes extracted over the mega-merged survey.
Figure 19. Phantom horizon slice 12 ms below the Pink Lime through the most positive principal curvature volume on the 1993-1996 vintage Watonga survey. Yellow arrows indicate incised channels. A-A’ and B-B’ vertical sections through the main valley fill in the Red Fork Formation. Note that A-A’ corresponds to B-B’ and B-B’ to C-C’ on Figure 32.
Figure 20. Phantom horizon slice 12 ms below the Pink Lime through the most positive principal curvature volume on the mega merged survey. Yellow arrows indicate the edges incised channels. Blue arrows indicate a possible wrench fault. A-A’, B-B’ and C-C’ vertical sections through the main valley fill in the Red Fork Formation.
Figure 21. Phantom horizon slice 12 ms below the Pink Lime through the most negative principal curvature volume on the 1993-1996 vintage Watonga survey. Yellow arrows indicate incised channels. Notice the poor delineation of the channel features. A-A’ and B-B’ vertical sections through the main valley fill in the Red Fork Formation.
Figure 22. Phantom horizon slice 12 ms below the Pink Lime through the most negative principal curvature volume on the mega merged survey. Yellow arrows indicate incised channels. Negative curvature values correlate to the channel thalweg. A-A’, B-B’ and C-C’ vertical sections through the main valley fill in the Red Fork Formation.
Figure 23. Phantom horizon slice 12 ms below the Pink Lime through the most positive principal curvature co-rendered with the Sobel filter similarity volume on the 1993-1996 vintage Watonga survey. Yellow arrows indicate incised channels. Notice how the edges of the channels are being delineated by the Sobel filter similarity and by the highest values of most positive curvature. A-A’ and B-B’ vertical sections through the main valley fill in the Red Fork Formation.
Figure 24. Phantom horizon slice 12 ms below the Pink Lime through the most positive principal curvature co-rendered with the Sobel filter similarity volume on the mega merged survey. Yellow arrows indicate incised channels. Notice the better delineation of the edges of the channels by the Sobel filter similarity and the highest values of most positive curvature. A-A’, B-B’ and C-C’ vertical sections through the main valley fill in the Red Fork Formation.
Figure 25. Phantom horizon slice 12 ms below the Pink Lime through most negative principal curvature co-rendered with the Sobel filter similarity volume on the 1993-1996 vintage Watonga survey. Yellow arrows indicate incised channels. A-A’ and B-B’ vertical sections through the main valley fill in the Red Fork Formation. Note that A-A’ corresponds to B-B’ and B-B’ to C-C’ on Figure 37.
Figure 26. Phantom horizon slice 12 ms below the Pink Lime through the most negative principal curvature co-rendered with the Sobel filter similarity volume on the mega merged survey. Yellow arrows indicate incised channels. Notice how the edges of the channels are being delineated by the Sobel filter similarity and the lowest values of most negative curvature can be associated with the channel thalweg. A-A’, B-B’ and C-C’ vertical sections through the main valley fill in the Red Fork Formation.
Spectral decomposition

Spectral decomposition is sensitive to subtle interference patterns, such as thin-bed tuning associated with channels in a plan view (Chopra and Marfurt, 2010). Since the data were previously spectrally whitened during the seismic processing stage, the spectral components exhibit the tuning effects of the geology with different channel thicknesses and infill exhibiting different spectral responses. In general, thinner beds will be better displayed with higher frequency components, and thicker beds with lower frequency components (Figure 27).

![Schematic diagram showing the effect of thin bed tuning analyzed using different frequencies](image)

Figure 27. Schematic diagram showing the effect of thin bed tuning analyzed using different frequencies (After Laughlin et al., 2002).

In Figures 25 and 26, the 14 Hz, 34 Hz and 54 Hz spectral components are co-rendered along a horizon slice extracted 12ms below the Pink Lime Formation. Note how the stages of fill are defined by the different frequencies.
Figure 28. Phantom horizon slice 12 ms below the Pink Lime displaying channel features highlighted by three spectral frequencies at 14 Hz (red), 34 Hz (green), and 54 Hz (blue) on the 1993-1996 vintage Watonga survey. Yellow arrows indicate incised channels. A-A’ and B-B’ vertical sections through the main valley fill in the Red Fork Formation.
Figure 29. Phantom horizon slice 12 ms below the Pink Lime displaying channel features highlighted by three spectral frequencies at 14 Hz (red), 34 Hz (green), and 54 Hz (blue) on the mega merged survey. Yellow arrows indicate incised channels. A-A’, B-B’ and C-C’ vertical sections through the main valley fill in the Red Fork Formation.
Coherent energy

The coherent energy attribute is a measure of the energy of the coherent component of the reflectors within the analysis window aligned along the dip and azimuth. High amplitude continuous features such as low impedance sands and high impedance limestones will exhibit high coherent energy. Low amplitude features (in this survey shale on shale reflectors) or high amplitude, incoherent features (such as karst in the deeper Hunton Formation) will exhibit lower coherent energy. A good way to better display the discontinuities, in this case channels, is to co-render the coherent energy attribute with the Sobel filter similarity (or any other edge detector attribute), such channel features are better visualized. Channels will often give rise to a very abrupt lateral change in amplitude giving rise to a low Sobel filter similarity anomaly (Figures 27 and 28).
Figure 30. Phantom horizon slice 12 ms below the Pink Lime through the coherent energy co-rendered with Sobel filter similarity volumes on the 1993-1996 vintage Watonga survey. Green arrows indicate incised channels. Notice the delineation of the channel by the Sobel filter similarity and how the channels fills are being highlighted by the coherent energy. Purple arrows indicate NS-EW footprint. A-A' and B-B' vertical sections through the main valley fill in the Red Fork Formation. Note that A-A' corresponds to B-B' and B-B' to C-C' on Figure 44.
Figure 31. Phatom horizon slice 12 ms below the Pink Lime horizon through coherent energy co-rendered with Sobel filter similarity volumes on the mega merged survey. Green arrows indicate incised channels. Notice the delineation of the channel by the Sobel filter similarity and how the channels fills are being highlighted by the coherent energy. A-A’, B-B’, and C-C’ vertical sections through the main valley fill in the Red Fork Formation.
Energy-weighted coherent-amplitude gradients:

The inline and crossline energy-weighted coherent-amplitude gradients are the horizontal derivatives of coherent energy in the analysis window (Chopra and Marfurt, 2007). They measure the lateral variation of amplitude across the analysis window along the dip and azimuth of the reflectors. When the gradients are high, there is a zone of rapidly varying high-amplitude coherent energy zone, and when the gradients are low, either the zone varies smoothly, has low energy, or the energy is incoherent.

These attributes emphasize subtle lateral changes in frequencies associated with edges. In this case study, the channel edges and the incoherent section of the channel fills are better highlighted using energy-weighted coherent-amplitude gradients co-rendered with coherent energy, than the similarity attributes previously presented (Figures 29-32).
Figure 32. Phantom horizon slice at 12 ms below the Pink Lime on the Watonga survey through the inline coherent energy (left) and crossline coherent energy (right). Purple arrows highlight the strong acquisition footprint present in the seismic survey. Green arrows indicate incised channels.
Figure 33. Phantom horizon slice at 12 ms below Pink Lime on the Watonga survey through the inline coherent energy co-rendered with crossline coherent energy and coherent energy volumes. Purple arrows highlight the strong acquisition footprint present in the seismic survey. Green arrows indicate incised channels. Notice the delineation of the channels by both coherent energy component and how the channels fills are being highlighted by the coherent energy. Purple arrows indicate NS-EW footprint. A-A’ and B-B’ vertical sections through the main valley fill in the Red Fork Formation. Note that A-A’ corresponds to B-B’ and B-B’ to C-C’ on Figure 46.
Figure 34. Phantom horizon slice at 12 ms below the Pink Lime on the mega merged survey through the inline coherent energy (left) and crossline coherent energy (right). Note that acquisition footprint has been diminished in the mega merged seismic survey, which increased the signal to noise ration. Green arrows indicate incised channels better delineated in this seismic survey than in the Watonga.
Figure 35. Phantom horizon slice at 12 ms below Pink Lime on the mega merged survey through the inline coherent energy co-rendered with crossline coherent energy and coherent energy volumes. Purple arrows highlight the strong acquisition footprint present in the seismic survey. Green arrows indicate incised channels. Notice the delineation of the channels by both coherent energy components and how the channels fills are being highlighted by the coherent energy. Purple arrows indicate NS-EW footprint. A-A', B-B', and C-C' vertical sections through the main valley fill in the Red Fork Formation.
Conclusions

Careful re-processing of legacy seismic data can significantly improve the delineation of geologic features such as the Red Fork incised valleys. Specifically, improvements in surface-consistent statics, tomographic refraction statics, surface-consistent deconvolution, and velocity analysis provide more coherent images with greater bandwidth and lateral resolution. Careful prestack trace balancing diminishes acquisition footprint, which dominates not only edge-sensitive coherence and curvature attributes, but also spectral components and impedance inversion.

Merging multiple surveys improves the delineation of geology at and beyond the survey edges, providing a more regional stratigraphic interpretation context. Seismic scattering from faults, channel edges, and other diffractors result in data under the acreage of interest being scattered into adjacent surveys. Such scattered information may have been or could be acquired by 3D surveys adjacent to the acreage of interest, and by the selection of an appropriate “migration aperture” can be imaged back to the correct location. For this reason surveys reprocessed as a unit in a megamerge effort provide images that are sharper, higher resolution and less wormy than simply phase matching adjacent but separately processed legacy surveys.

ACKNOWLEDGEMENTS

This work would not be possible without the generous provision of data licenses and software. Licenses to the original Watonga survey, to 800 well logs, and most important, the geological insight was provided by Chesapeake Energy. A license to the reprocessed, and significantly larger, megamerge survey was provided by CGG-Veritas. Interpretation was done using licenses provided by Schlumberger. Most of the attributes were generated using software developed as part of the industry-sponsored OU Attribute-Assisted Seismic Processing and Inversion (AASPI) consortium.
REFERENCES


