

**GEOPHYSICALCORNER**

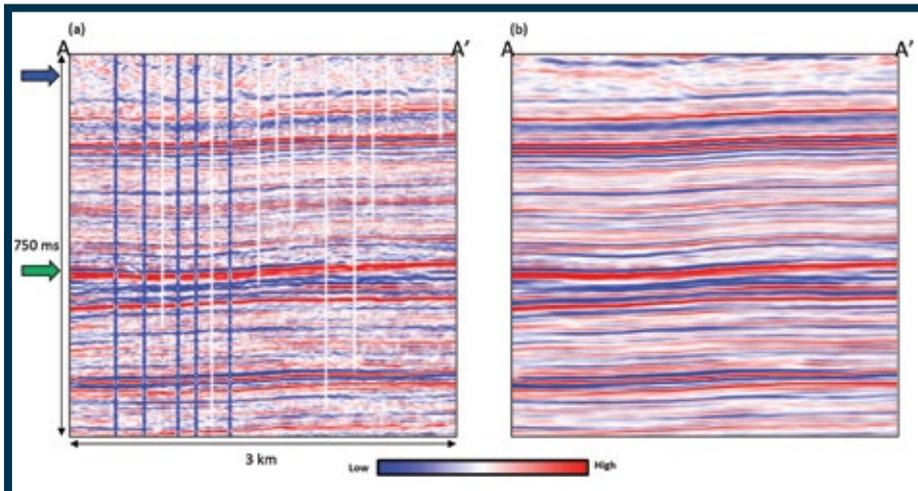
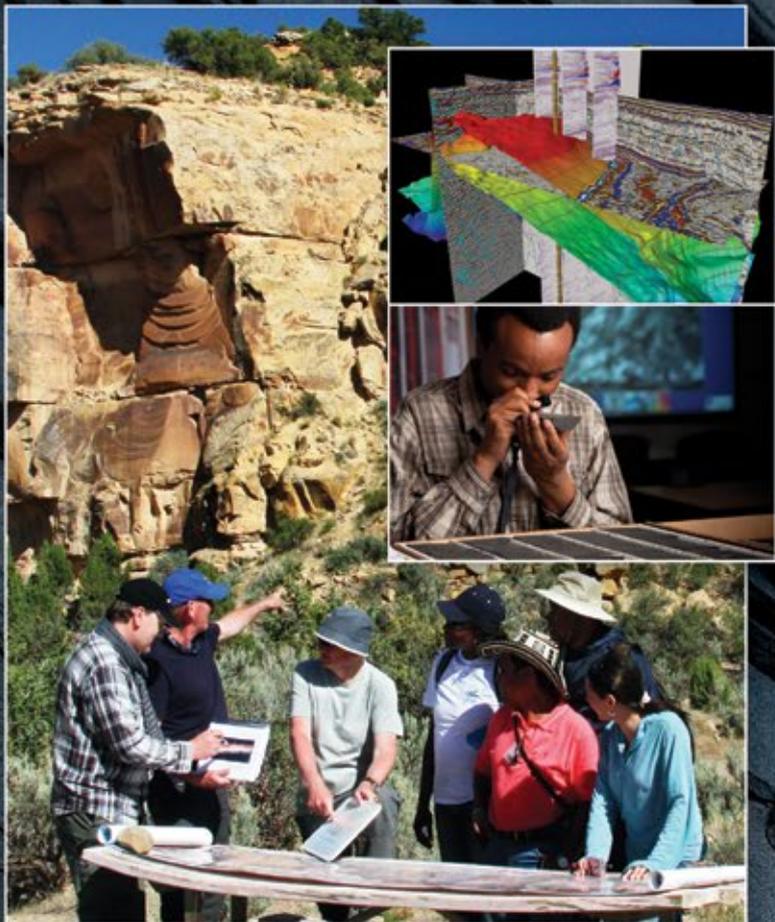


Figure 1 – Vertical seismic sections through the seismic volume (a) before, and (b) after 5-D interpolation.

*Confident displays*

# Finding the Path Past 'Attribute Footprints'

By SATINDER CHOPRA and KURT J. MARFURT

Three-D seismic surveys usually are designed in a way that the subsurface features are regularly sampled in different dimensions, comprising the spatial coordinates, offsets and azimuths.

Many processing algorithms require this regularity for their optimum performance. For example:

- ▶ Marine acquisition suffers from platforms, shallow shoals, and tides and currents that give rise to feathering, all of which result in irregularity in spatial sampling of the data.

For older marine surveys, inlines are well sampled while crosslines are more coarsely spaced.

- ▶ Land acquisition encounters a different suite of obstacles, such as highways, buildings and lakes.

Such obstacles, coupled with limited recording capacity and greater cost, results in missing data or "holes" in seismic data coverage.

- ▶ Finally, recording equipment malfunctions and noise bursts during acquisition may add more missing traces to the usable recordable data.

Sparse or missing data create problems while processing, as the

different algorithms applied pre-stack or post-stack demand regularity in the offset and azimuth dimensions for optimum performance.

Non-uniformity in offsets and azimuths leads to inconsistencies in fold that follow a regular pattern we refer to as "acquisition footprint." This imprint is an undesirable artifact that masks geologic features or amplitude variations seen on time slices from the seismic data, especially at shallow times.

Besides, the seismic data-derived attribute volumes also show acquisition footprint and other artifacts.

Obviously, the ideal way to fill in the missing data gaps would be to reshoot the data in those areas – although such infill acquisition would be extremely expensive per data point, if the equipment could be made available for such a small time in the field.

Such problems have been addressed at the processing stage since the advent of digital processing. The most common preconditioning of seismic data improves the signal-to-noise ratio of the seismic data by removing spatial



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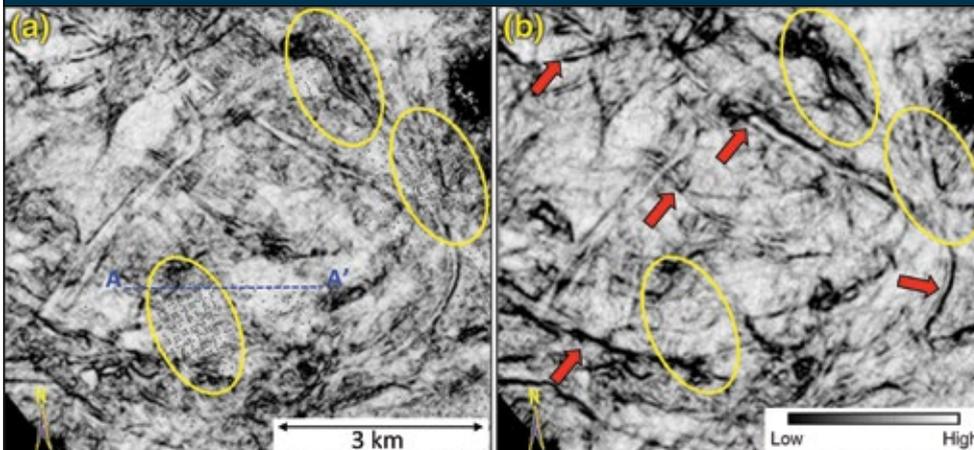
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Figure 2 – Horizon slices a few milliseconds above the marker indicated with the green arrow in figure 1a, from the coherence volumes computed from seismic data (a) before, and (b) after 5-D interpolation.



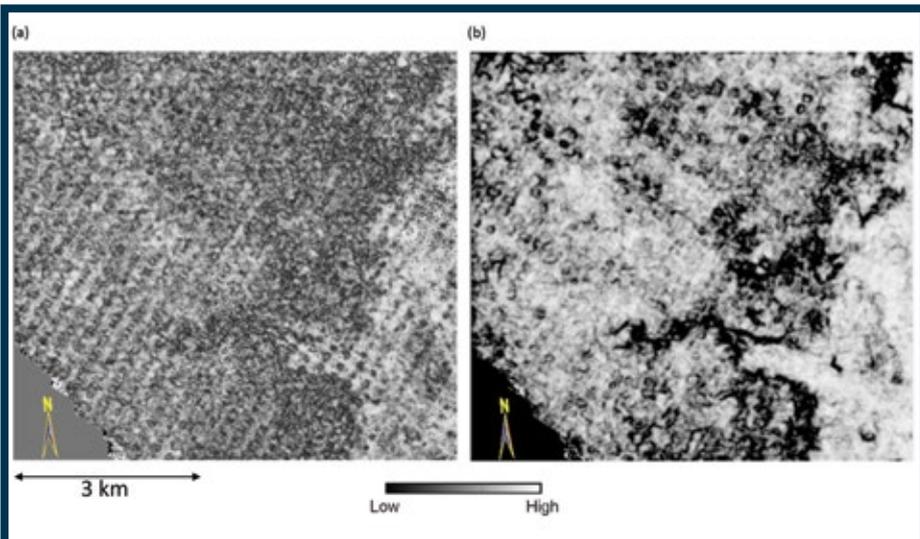


Figure 3 – Time slices at the level of the blue arrow in figure 1a, through the coherence volumes computed from seismic data (a) before, and (b) after 5-D interpolation.

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noise or enhancing the coherency and alignment of the reflection events, without unnecessary smoothing or smearing of the discontinuities.

Although we usually think of removing unwanted features, we also can improve the signal-to-noise ratio by predicting unmeasured signal, such as dead traces and lower-fold areas corresponding to unrecorded offsets and azimuths in the gathers.

\* \* \*

Prediction or population of missing traces in seismic data is referred to as interpolation. Initial interpolation methods used localized information, such as creating a missing trace by taking the lateral average of measured adjacent traces.

These methods worked well on stacked data volumes. A geologic feature seen on seismic data has three dimensions – time, an easting (x) and a northing (y). However, modern seismic processes such as prestack impedance inversion uses a fourth dimension of source-receiver offset (h), while azimuthal anisotropy uses a fifth dimension of source-receiver azimuth.

The gap between the measured traces of a given offset-azimuth volume can be quite large, such that simple interpolation of spatial neighbors no longer works.

During the last decade or so, more sophisticated methods for data interpolation have evolved that interpolate the missing traces using not only in with neighboring samples in t, x and y, but also in offset and azimuth. Such “5-D” interpolators operate simultaneously in all dimensions, and are able to predict the missing data with more accurate amplitude and phase variations.

As expected, these methods are compute intensive and have longer run-times than the simplistic interpolation methods.

\* \* \*

We demonstrate here the application of one such method of 5-D interpolation on seismic data and show how it aids some of the seismic attributes derived from them.

In figure 1a we show a representative

vertical slice through a merged 3-D amplitude volume that has many dead traces. Such dead traces are seen on other inlines as well.

The location of this inline is shown in figure 2a, where we show a horizon slice through the corresponding coherence volume.

The dead traces result in the speckled pattern indicated with yellow ellipses. To regularize the data, 5-D interpolation was run on the seismic data prior to migration with the equivalent displays shown in figures 1b and 2b, respectively.

Notice in figure 1b that not only are the missing traces interpolated, but the overall signal-to-noise ratio and reflector continuity is improved.

Similarly, note the absence of the speckles associated with the missing traces and the greater continuity of the channel and other discontinuity features as indicated by the red arrows.

The inference we draw from this example is that regularization by 5-D interpretation yields better-focused images. Interpretation carried out on such attributes will definitely be more accurate than the one carried out on data without regularization.

\* \* \*

As 5-D interpolation discussed above regularizes the geometry of the seismic data, it addresses the root cause of the footprint arising due to the acquisition irregularities.

In figure 3a we show time slices at 158 ms, where the acquisition footprint appears prominently on the coherence attribute as striations in the NE-SW direction masking the reflection detail behind them. Figure 3b shows the equivalent coherence slice after 5-D regularization exhibiting considerable improvement in data quality.

Seismic data usually have geometry regularization issues that give rise to artifacts on geometric attribute displays. Five-D interpolation methods adopted during processing help address issues such as missing data pockets and acquisition footprint striations.

Coherence and curvature attributes computed on regularized seismic data yield displays clear of these artifacts, and so lead to more confident displays.

We thank Arcis Seismic Solutions, TGS, for encouraging this work and for permission to present these results.

*Editor's note: AAPG member Kurt J. Marfurt is with the University of Oklahoma, Norman, Okla.* 

# FOUNDATION GRANTS FOR UNDERGRADUATE STUDENTS



The L Austin Weeks Undergraduate Grant Program for 2012-13 is made possible through a generous gift from the late L Austin Weeks and Marta Weeks-Wulf. In 2013, there are 61 recipients. Qualified student applicants and their AAPG Student Chapters receive \$500 each. The purpose of the grant is to support educational expenses of undergraduate geoscience students and their departments. With more than 300 student chapters operating, the need is very great. Consider supporting this fantastic grant program.



### To the AAPG Foundation.

On behalf of the University of Iowa Student Chapter, Thank you!

Meredith Petrie  
University of Iowa  
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President



### A thankful student

I feel extremely blessed to receive this scholarship and our AAPG chapter is very thankful as a whole for the money you have provided. The chapter will use the money to fund our yearly AAPG field trip. This year, we will be going to Sudbury to look at the different types of mineralization. I will personally use the money provided to pay for our exploration geology field trip and new articles of field gear.

After I graduate in the fall, I plan on pursuing my masters in geochemistry and stratigraphy. My long-term goals involve working in the petroleum exploration industry. This summer I will participate in a short course with Exxon Mobil. The grant you provided has helped prepare me to succeed in this course and obtain my goals.

Again, thank you very much.  
Samuel H. Saltzman

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