

# Let's Get Small: Benefits of Reduced Bin Size

By SATINDER CHOPRA and KURT J. MARFURT

Ideally, seismic data should be acquired at high spatial and temporal sampling, so that the small subsurface features of interest can be clearly seen on the seismic display.

Such interpretation is easiest when the geological features of interest are uniformly illuminated, which in turn is possible by recording the scattered seismic wavefield on a uniform surface grid. The "nominal grid" is defined by the source-to-source spacing within a shot line and the geophone-group-to-geophone-group spacing within a receiver line.

One also can increase the trace density by reducing the spacing between shot lines and between receiver lines.

Once acquired, data processing workflows are designed to retain the highest possible lateral and vertical resolution of the geologic target. Because of the different ray paths, dense acquisition (closer source and receiver lines) provides greater leverage against backscattered ground roll and interbed multiples, as well as decreased migration artifacts.

Uniform acquisition results in increased lateral continuity of amplitudes that otherwise may be contaminated by acquisition footprint.



CHOPRA



MARFURT

\* \* \*

In reality, economic, permitting and physical access constraints result in 3-D seismic data that are not uniformly sampled in all directions.

Vibrators require access along roads or open country, while geophones easily can be placed in forest or cultivated farmland. For this reason, "shot lines" may be more coarsely spaced than "receiver lines," resulting in rectangular rather than square bins. Obstacles such as ponds, road, buildings and archaeological sites give rise to holes in an otherwise uniform acquisition grid.

Such non-uniformity in offsets and azimuths introduce additional artifacts in the final image. This non-uniformity also affects the performance of the processing algorithms – and so could lead to sub-optimally processed data, affecting subsequent data interpretation.

In principal, any processing algorithm can be modified to handle sparse data. In practice, it is much easier to write an accurate 5-D interpolation algorithm, and thereby precondition the seismic data such that well-calibrated (and perhaps more complicated) algorithms such as prestack migration and prestack inversion work well.

\* \* \*

While there is no substitute for acquiring good quality seismic data that has the above-mentioned qualities, it is possible to mimic or address some of the problems that crop up due to the sub-optimum parameterization used in the acquisition,

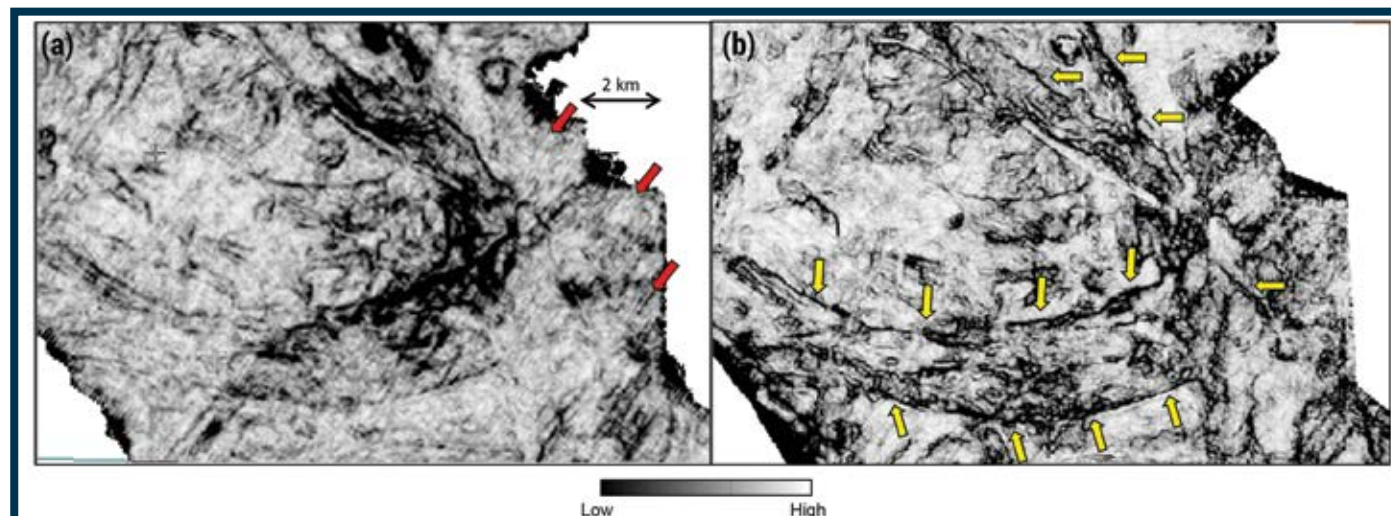


Figure 1 – Stratal slices through coherence volumes close to a shallow marker horizon at  $t=600$  ms generated from 5-D interpolated data at (a) nominal 20 m by 20 m and (b) finer 10 m by 10 m bin size. Red arrows indicate a pervasive footprint. Yellow arrows indicate features at higher resolution.

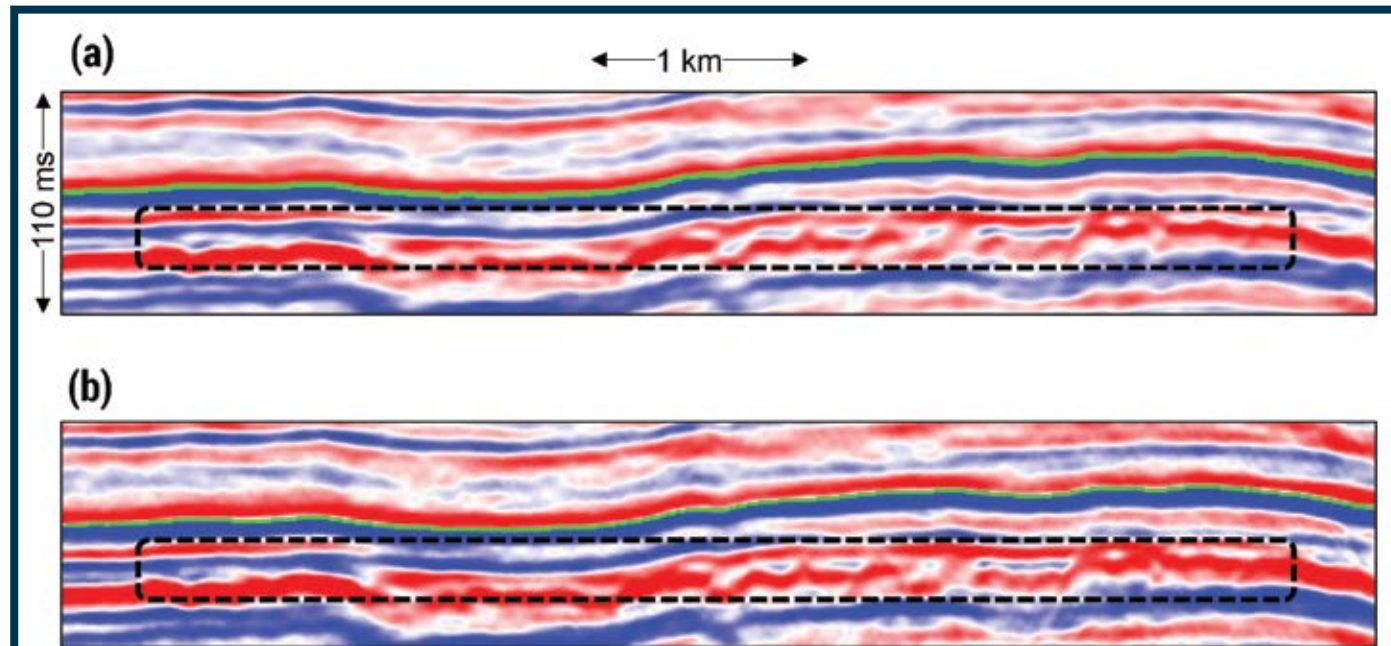


Figure 2 – Vertical slice corresponding to the blue dotted line shown in figure 3 through seismic amplitude volumes generated using 5-D interpolation generated from 5-D interpolated data at (a) nominal 20 m by 20 m and (b) finer 10 m by 10 m bin size. Black box indicates channels delineated by coherence in figure 3.

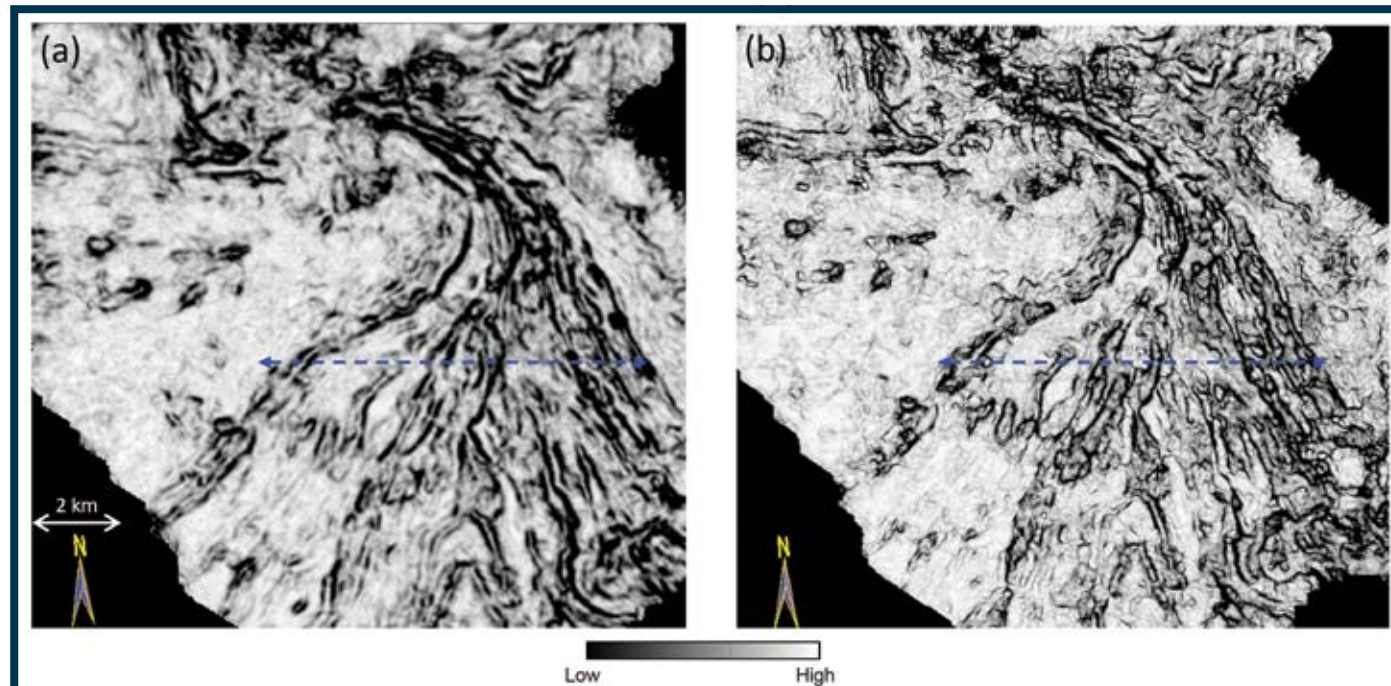


Figure 3 – Phantom horizon slices 20 ms below the green horizon shown in figure 2 through coherence volumes generated from 5-D interpolated data at (a) nominal 20 m by 20 m and (b) finer 10 m by 10 m bin size. Blue line corresponds to vertical slice shown in figure 2. Notice the crisp definition of the limbs of the distributary channel system.

during processing of the data.

In the June 2013 EXPLORER, we described the advantages of regularizing the offsets and azimuths of the input seismic data during processing by way of 5-D interpolation, which then aids the

computation of seismic attributes.

Regularization of seismic data has proven to be a successful method – not only for superior imaging of post-stack data but for prestack analysis as well, such as AVO (amplitude versus offset)

or AVAz (amplitude versus azimuth). The advantages accrue from the enhanced spatial and azimuthal sampling of the 3-D seismic data.

See Geophysical Corner, page 50



# Applied Geoscience Conference



## INTEGRATED APPROACHES TO UNCONVENTIONAL RESERVOIR ASSESSMENT AND OPTIMIZATION

Please join us for the Houston Geological Society's premier technical Conference!

Our 2014 program includes:

- Eight (8) Session Oral Technical Program
- Student Posters / Industry support University Research
- Cores supporting Oral Technical Program

The eight sessions of our technical program feature talks by invited experts.

The *Applied Geoscience Conference* offers you the latest breakthroughs, technical perspectives, and integrated approaches to unconventional reservoir assessment and optimization.

### REGISTRATION IS NOW OPEN!

FOR MORE INFORMATION PLEASE VISIT [WWW.HGS.ORG](http://WWW.HGS.ORG)

## February 17-18, 2014

WESTIN MEMORIAL CITY • 945 Gessner Road • Houston, TX 77024  
For special room rates call before February 1st: 281-501-4300





## Policy Watch from page 46

on regulation. In fact, BLM praised the sophisticated and effective oversight of state regulators and sought consistency with API standards.

The initial (2012) draft of BLM's proposed hydraulic fracturing rules included a requirement to submit a cement bond log before hydraulic fracturing, and required publication of hydraulic-fracturing fluid chemistry.

After thousands of comments were submitted, BLM revised its proposed rules to ones that more closely mirror – industry would say needlessly duplicate – industry best practices.

The revised draft rules allow an expanded set of cement evaluation tools

for demonstrating well bore integrity for “type wells,” or wells that exemplify many wells in an area. Other wells would be subject to monitoring of cementing operations.

The revised rules are generally consistent with the API technical report on “Cement Sheath Evaluation,” which observes that a cement bond log is only one of several evaluation tools that should be used in connection with other well and cement data to evaluate zonal isolation.

In addition, the BLM draft rules also would use FracFocus, the industry standard for disclosure of chemicals used in hydraulic fracturing.


\* \* \*

But this is not the end of the story.

The comment period for the proposed rules ended Aug. 25, and BLM has reported that it received over one million comments, enough to require months of analysis and probably lead to additional modifications in the draft rule.

It should be noted that government adoption of some industry best practices does not address industry concerns about some other regulations that complicate or conflict with industry best practices.

The major industry and state complaint is the imposition of an additional layer of federal regulations on top of state regulations.

API commented that the BLM “... proposed rule on hydraulic fracturing would impose an added regulatory layer that would be costly and provide little or no environmental or safety benefit.” 

## Geophysical Corner from page 48

After doing the trace edits, amplitude recovery, refraction statics, preliminary velocity analysis and trim statics, one can run 5-D interpolation to “regularize” the data to have a uniform coverage of offsets and azimuths, thereby conditioning them for more detailed velocity analysis, noise rejection, prestack time migration and prestack impedance inversion.

In our June 2013 article we showed how such 5-D interpolation reduced artifacts in amplitude as well as in coherence and curvature attributes, but somewhat reduced the lateral resolution.

\* \* \*

In this article we demonstrate the results of reducing the bin size of the seismic data as part of the 5-D interpolation process.

The source and receiver spacings are both 40 meters, giving rise to a nominal bin size of 20 meters by 20 meters. The primary use of 5-D interpolation is to fill in missing shots, receivers, offsets and azimuths corresponding to the nominal grid.

However, there is nothing preventing us in postulating a denser 10-meter by 10-meter grid and interpolating the corresponding unmigrated surface data. This smaller bin size is the interpolated equivalent of a (four times) more densely acquired survey.

We then use the same processing and prestack migration procedure applied to the interpolated data on the 20-meter by 20-meter grid.

The results we show are from a land seismic data volume from western Canada. We used 5-D interpolation to build missing traces for both 20 by 20 and 10 by 10 bin sizes.

► In figure 1 we show a comparison of coherence horizon slices generated from data with 5-D interpolation at the nominal 20-meter by 20-meter bin size and at the “dense survey” 10-meter by 10-meter bin size.


Notice the enhanced resolution of the faults and the suppression of the NE-SW trending acquisition footprint.

► A comparison of the seismic amplitude data before and after bin size reduction is shown in figure 2.

In the dashed box we notice somewhat clearer seismic signatures corresponding to the channel features that can be seen on the coherence phantom horizon slices comparison shown in figures 3.

Although the distributary channel system seen on the coherence slices is well imaged at the nominal grid size, the interpolated surface data provide much sharper individual channel limbs. Such enhanced quality imaging of data in terms of suitable seismic attributes helps squeeze out more information from the seismic data – and contributes in a generous way to the overall interpretation of the data as well.

\* \* \*

We thank Arcis Seismic Solutions and 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.)

# UNCONVENTIONAL INSIGHTS



Optimize unconventional plays with a focused, integrated portfolio of technologies. Weatherford can partner with you from start to finish, helping you identify where to drill, how best to secure your wells, where to frac and how to maximize production. And you can count on us to deliver exclusive innovations like the SpectralWave™ spectral azimuthal gamma ray—a proven technological advantage that locates “sweet spots” to help keep you on target and in the pay zone.

Weatherford delivers best-in-class expertise through our multidisciplinary Unconventional Resource Team. We provide an integrated workflow of sophisticated logging, leading-edge laboratory analysis, comprehensive stimulation, multizone completion design and production technologies.

Contact and collaborate with our Unconventional Resource Team at [unconventional@weatherford.com](mailto:unconventional@weatherford.com).