[GC]Improving the Quality of Coherence and Curvature Attributes by Using Multispectral Dip Components*

Satinder Chopra[1] and Kurt J. Marfurt[2]

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[1]TGS, Calgary, Canada (schopra@arcis.com)
[2]University of Oklahoma, Norman, Oklahoma, USA

General Statement

Coherence and curvature are iconic attributes now commonly available on most interpretation workstations that help characterize small- and large-scale faults, large fractures, pinch-outs, buried channels, reef edges and unconformities. The quality of both these attributes, among other factors, relies on accurate estimates of volumetric dip. Coherence, amplitude gradients and GLCM texture attributes (see Spectral Decomposition Methods: Applicability and Limitations, Search and Discovery Article #41323 and Extracting Information from Texture Attributes, Search and Discovery Article #41330) should be computed along structural dip, while curvature (see Curvature Computations Enhance Exploration, Search and Discovery Article #40838) is computed from volumetric estimates of structural dip. Due to differences in both resolution and sensitivity to coherent noise, different frequency components might exhibit different dip. Such awareness has led to the development of multispectral coherence (see Multispectral Coherence Attribute Applications, Search and Discovery Article #42258) that makes use of summation of covariance matrices of individual spectral components, rather than just the covariance matrix computed from broadband seismic data. The same concepts are extended to compute multispectral dip components using a gradient structure tensor computation. These high-resolution dip estimates result in higher resolution curvature as well as continuous, less noisy discontinuities as seen on coherence attribute displays.

Quite often it is found that the conventional broadband seismic data do not necessarily provide the best insight into the interpretation of subsurface structure and stratigraphy, nor for the evaluation of the derived seismic attributes. Geologic discontinuities, for example, exhibit different seismic expressions as per their intrinsic scales, and can often be seen better at a specific frequency range. The literature shows that faults are often better delineated by lower frequency components, while stratigraphic features are often better delineated at frequencies near tuning. Coherence anomalies seen at multiple frequency scales can be combined using RGB color blending.

In Multispectral Coherence Attribute Applications, Search and Discovery Article #42258 the authors of this article explained how the energy ratio coherence performed on voice components within the frequency band of the input seismic data yields with more accurately defined geologic features. With this observation providing enough motivation, the authors showed that covariance matrices extracted using the same dip magnitude and azimuth are computed for each spectral band and summed prior to coherence computation. The concept of multispectral computation is now extended to dip and azimuth determination, and we find interesting and encouraging results.

There are various ways of estimating volumetric dip and azimuth, but two of the more common methods are the discrete semblance scans and the gradient structure tensor methods. In general, while the semblance-based dip estimation provides slightly better lateral resolution, the GST algorithm provides slightly better angular resolution. We show some applications of the latter method below.

For multispectral dip, the GST is computed for each spectral voice component within the bandwidth of the data and summed. The first eigenvector of the summed GST is the unit normal of a plane that best fits the data, thereby providing an estimate of dip and azimuth. Dip is a vector quantity, and dip vectors are composed of inline and crossline components, which most interpreters prefer to display as separate or co-rendered dip azimuth and dip magnitude components.

Application of Multispectral Dip/Azimuth for Coherence Computation

In Figure 1 we show a stratal slice 94 milliseconds below a seismic marker from a survey acquired in Alberta through the inline dip components, computed the traditional way (Figure 1a) and computed using our multispectral dip algorithm (Figure 1b). The east-west inline dip component accentuates north-south trending events. We identify prominent lineaments with different colored arrows at end points on both displays and note an improvement not only in continuity and lateral resolution, but also in the range of the dip values. Both computations were done using 99 nine (3 by 3) trace by 20 millisecond analysis overlapping Kuwahara windows. Figure 1c shows the corresponding results on the north-south crossline dip component, which, as expected, accentuates east-west dipping events. These east-west anomalies appear both more continuous and less smeared on the multispectral dip results.

In Figure 2 we show an overlay comparison of most-negative curvature (short-wavelength) using transparency over the most-positive curvature (short-wavelength) display for both volumetric dip estimates. We notice more focused lineaments and swarms of lineaments on the curvature attributes computed with the use of multispectral dips as indicated with the multicolored block arrows.

Finally, we draw comparisons between broadband energy ratio coherence displays as shown in Figure 3, without and with the use of multispectral dip components, respectively. Again, individual lineaments are indicated with colored arrows at their ends. Notice the higher signal-to-noise ratio and better continuity definition of the lineaments on both displays after using multispectral dip components in the two coherence displays.

Conclusions

As seen in the examples cited above, attributes such as inline dip, crossline dip, dip magnitude, dip azimuth, and broadband energy ratio coherence all benefit with the use of multispectral dip components in their computation. These benefits include better signal-to-noise ratio, more focused and continuous definition of lineaments or channel/reef edges (not shown). Although computationally more intensive, we recommend that multispectral dip components should be carried out for the generation of such attributes, which will enable more accurate interpretation, and which is the bottom line for a seismic interpreter.

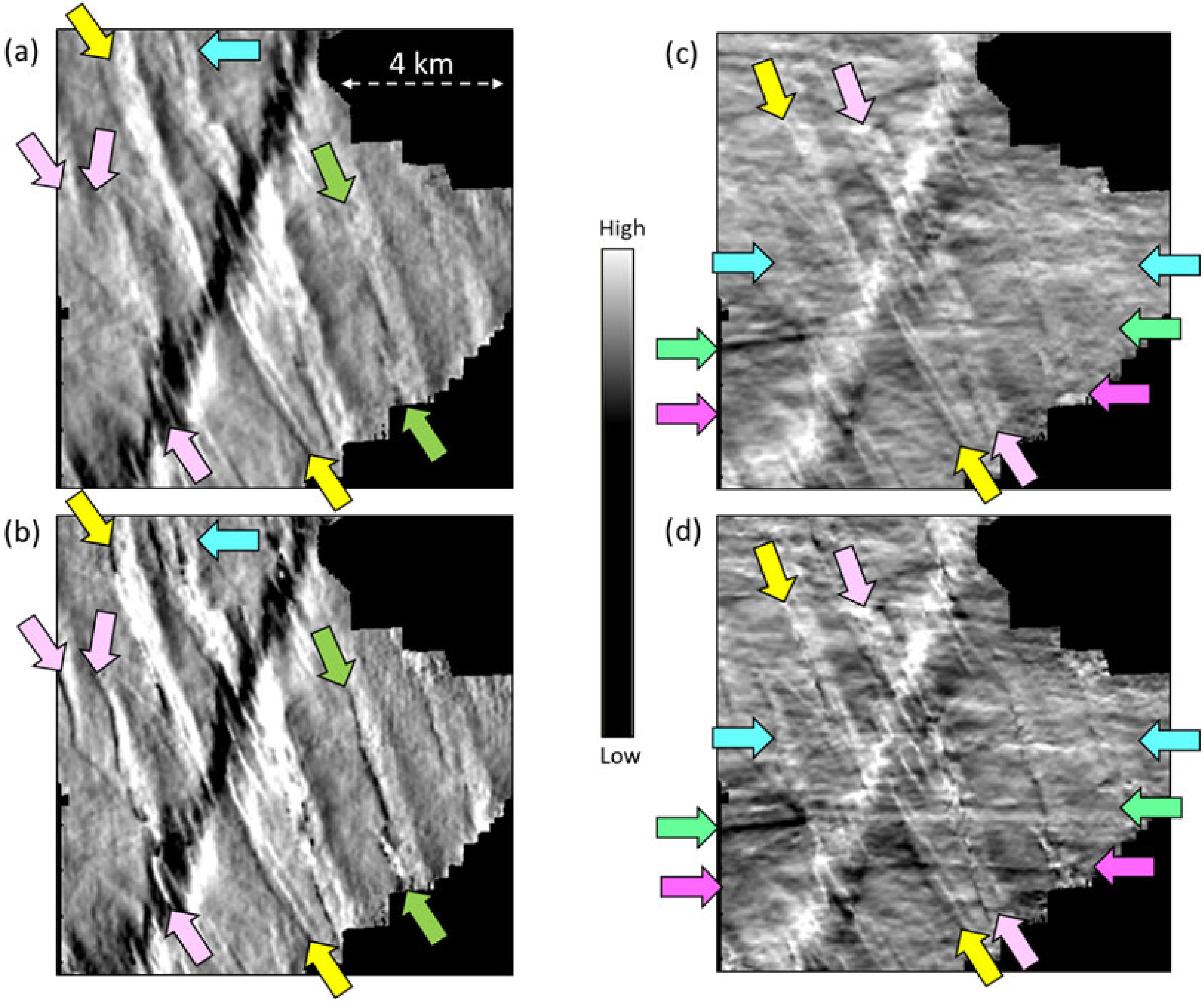

Figure 1. Stratal slices from inline dip volume 94 milliseconds below a marker, when multispectral dips were (a) not used, and (b) used in the computation. Stratal slices from crossline dip volume 94 milliseconds below a marker, when multispectral dips were (c) not used, and (d) used in the computation. Both computations used the same 9 trace by 20 millisecond window. Data courtesy of TGS Canada.

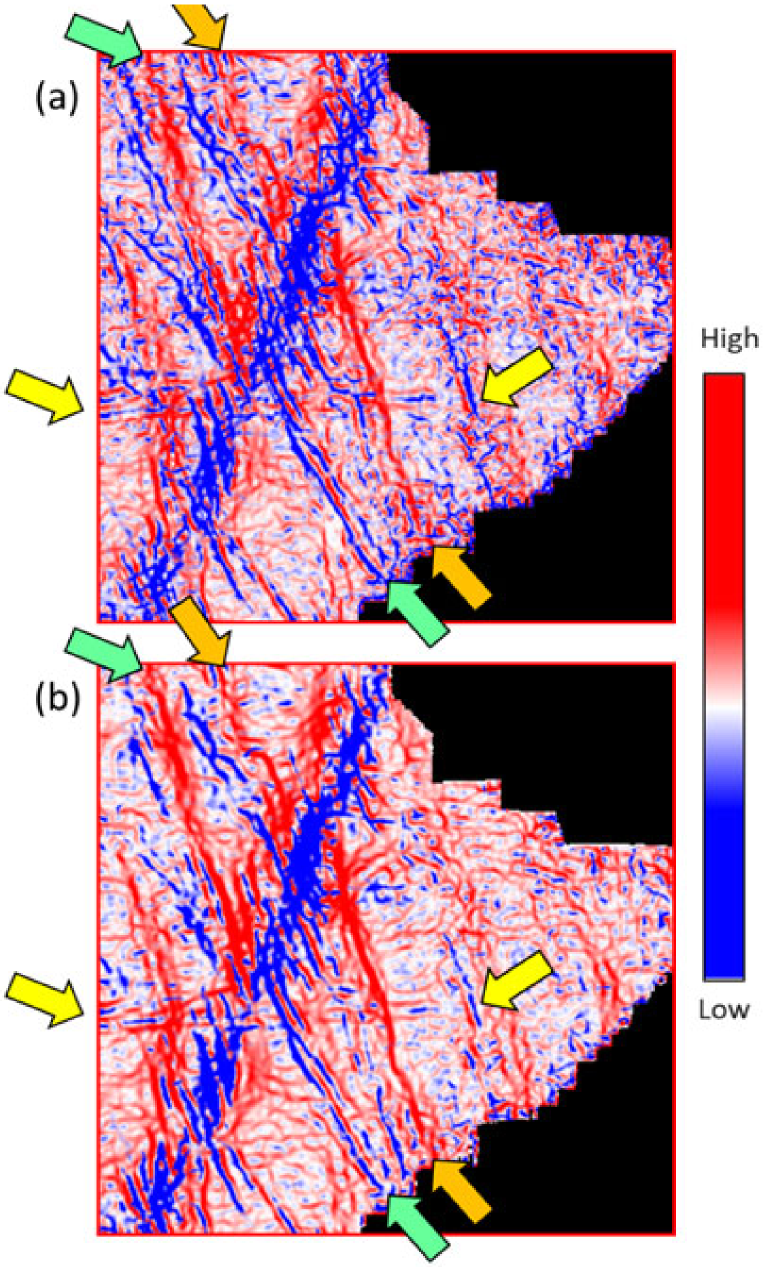

Figure 2. Stratal slice overlay of most negative curvature (short-wavelength) using transparency over the most-positive curvature (short-wavelength display 94 milliseconds below a marker, when multispectral dips were (a) not used, and (b) used in the curvature computation.

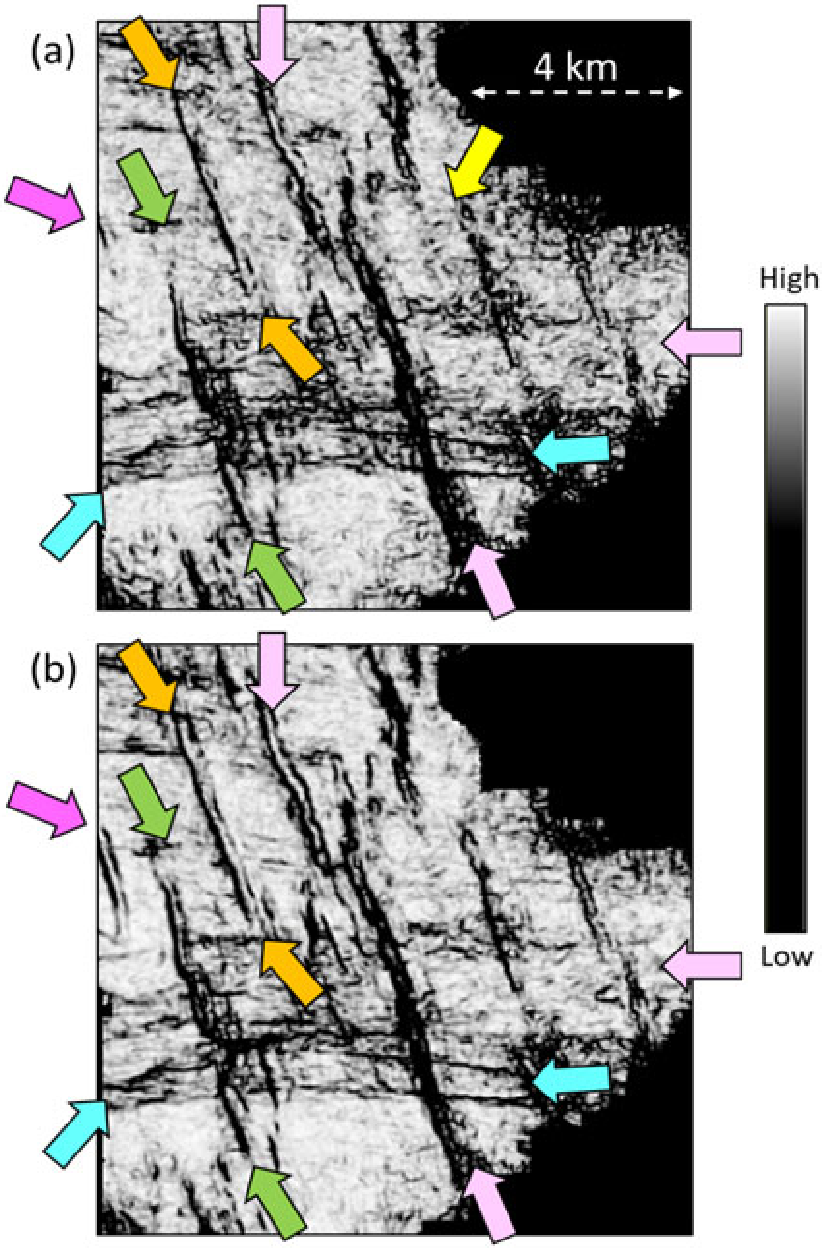

Figure 3. Stratal slices from broadband energy ratio volume 94 milliseconds below a marker, when multispectral dips were (a) not used, and (b) used in the computation.