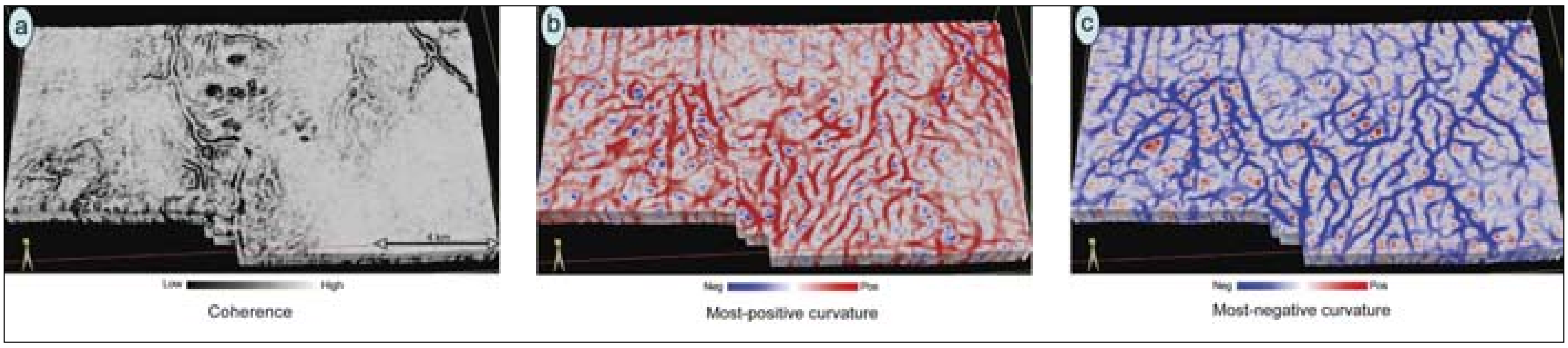
AAPG EXPLORER



Data courtesy of Arcis Corporation, Calgary

Figure 1 – Strat-slices through (a) coherence, (b) most-positive curvature and (c) most-negative curvature. We see some of the channel edges on the coherence display, but the most-positive curvature highlights most of the channel flanks and levee complexes. The thalweg (or channel-axis) for most channels is best seen on the most-negative curvature.

GEOPHYSICAL CORNER

Curvature Can Be a Map to Clarity

(The Geophysical Corner is a regular feature in the EXPLORER, edited by Bob A. Hardage, senior research scientist at the Bureau of Economic Geology, the University of Texas at Austin. This month's column, the second of a two-part series, deals with seismic curvature attributes: mapping depositional and diagenetic features.)

By SATINDER CHOPRA
and KURT J. MARFURT

Last month's Geophysical Corner illustrated the application of the most-positive and most-negative curvature attributes for detecting faults and fractures and calibration with borehole image-log data.

This month we illustrate the application of these attributes for mapping channels, levees and other stratigraphic features – particularly in older rocks that have undergone differential compaction.

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In figure 1 we generate strat-cube displays through volumetric estimates of coherence, combined with most-positive and most-negative curvatures. A strat-cube is a sub-volume of seismic data or its attributes, either bounded by two horizons that may not necessarily be parallel, or spanning seismic data above and/or below a given horizon.

The displayed surfaces are 4 ms below the horizon used for generating the strat-cube.

Notice the clarity with which the north-south main channel stands out and a second channel in the top-right corner.

Because of differential compaction and the presence of levees, the most-positive curvature defines the flanks of the channels, potential levees and overbank deposits. The most-negative curvature highlights the channel axes or thalwegs.

The coherence image is complementary and is insensitive to structural deformation of the surface; instead, it highlights those areas of the channel flanks where there is a lateral change in the waveform due to tuning.

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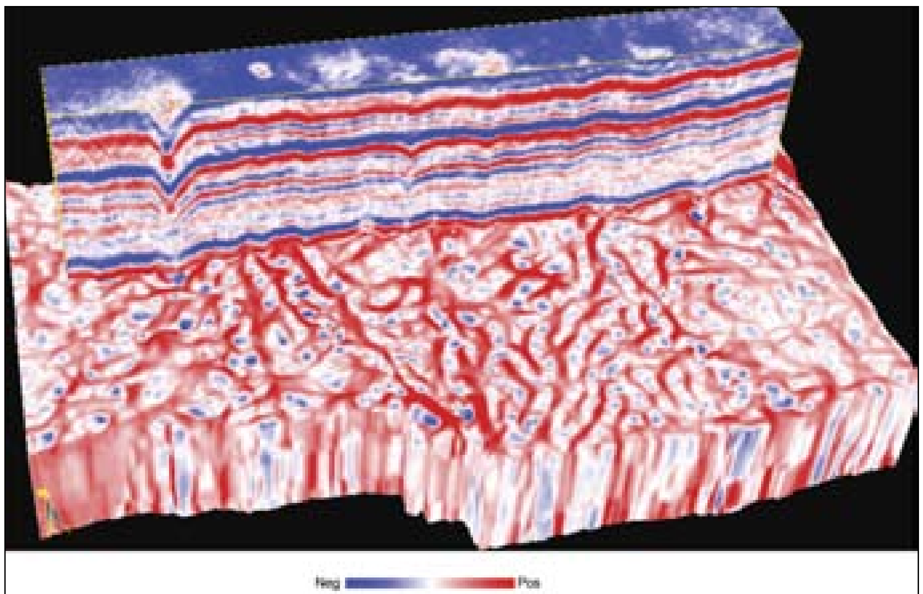
In figure 2 we show a chair display for a strat-cube constructed from the most-positive curvature attribute volume and an associated seismic profile.

Notice how the lineaments corresponding to the levees of the channels correlate with the localized "highs" on the seismic section.

Once an interpreter is able to see such a convincing correlation, the interpretation of smaller lineaments can be performed with more confidence.



Data courtesy of Arcis Corporation, Calgary

Figure 2 – Strat-cube through most-positive curvature allows an interpreter to correlate features on the attribute with their corresponding seismic signature. We see that some of the channel edges on the most-positive curvature correlate with local "highs" on the seismic data. Channel thalwegs seen in figure 1c correlate with local "lows" on the seismic data.

* * *

In figure 3 we re-examine a survey discussed in detail by Sagan and Hart in the November 2006 special AAPG BULLETIN issue on hydrothermally altered dolomite.

In figures 3a and 3b we display time slices through the most negative curvature volume at approximately the Trenton and basement levels. Note that by using a volumetric estimate of curvature, we can map the same diagenetically altered zones at the Trenton level and faults in the basement discussed by Sagan and Hart.

Sagan and Hart show how the structural control and diagenetic alteration result in a suite of en echelon valley-like features running northwest-southeast through the survey.

Conclusions

Like all attributes, curvature is valuable only when coupled with a geologic model of structural deformation, stratigraphic deposition or diagenetic alteration.

Curvature is particularly sensitive to flexures and faults.

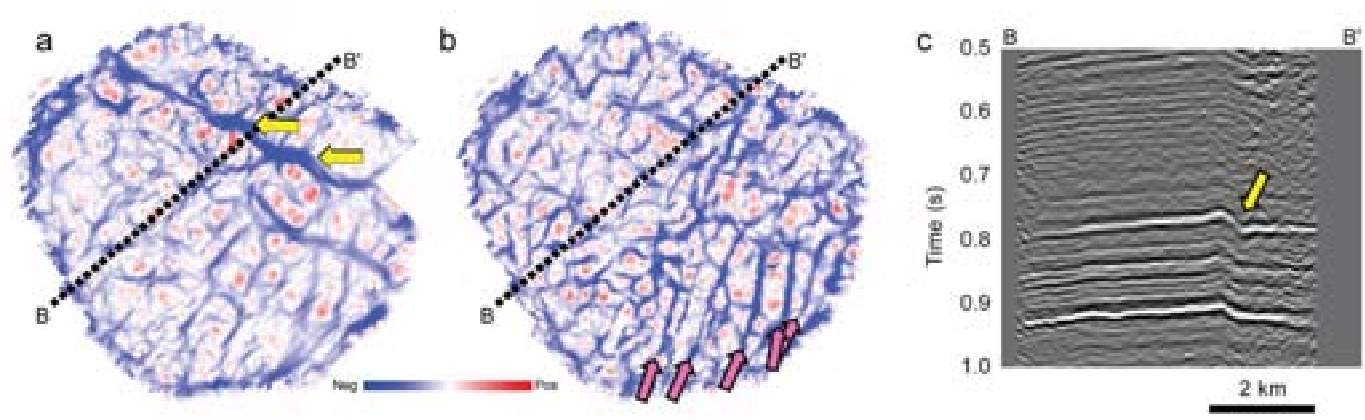
Curvature can be a powerful tool in mapping channels, levees, bars, contourites and other stratigraphic features, particularly in older rocks that have undergone differential compaction.

Discrete fractures often appear on most negative curvature. This behavior can be caused by sags about the fractures or by local velocity changes associated with stress, porosity, diagenetic alteration or fluid charge.

Although curvature attributes calculated on time surfaces after spatial filtering can display interesting features, volumetric curvature attributes provide more valuable information on fracture orientation and density in zones where seismic horizons are not trackable. ❑

We thank Arcis Corporation for permission to show the data examples and publish this work.

(Editor's note: Chopra is with Arcis Corp., Calgary, Canada; Marfurt is with the University of Oklahoma. Both are AAPG members.)



Data courtesy of CGAS, Columbus, Ohio

Figure 3 – Time slices at (a) t = 0.80 s (approximate Trenton) and (b) t = 0.94 s (approximate basement) through the most-negative curvature volume computed from a survey acquired over Saybrook field, northeastern Ohio. (c) Vertical slice through the seismic data. Yellow arrows indicate hydrothermally altered dolomite zones. Magenta arrows indicate faults in the basement.