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Delineating Karst features using Advanced Interpretation

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Summary

We use "Amplitude, Instantaneous Phase, Trace Envelope and Dip of Maximum Similarity" Attributes as a tool to delineate Karst induced features in the Boonsville area of North Central Texas. The applications of these Attributes will demonstrate how these seismic attributes can be creatively utilized to achieve interpretational objectives beyond those from only the conventional seismic data. Our application thus comprises the creative use of certain effective and well-known attributes in conjunction with the regular seismic data to facilitate structural and stratigraphic interpretation of the geo-bodies. The expediency, accuracy and thoroughness of resultant interpretations are often beyond those of conventional interpretation.

Introduction

Instantaneous Phase (degrees) is the argument of the analytic signal: The phase information is independent of trace amplitudes. In a number of displays 8 different colors are sufficient. These colors represent 45-degree phase increments. The phase information it relates to the propagation phase of the seismic wave front. Since, most of the time, wave fronts are defined as lines of constant phase, the phase attribute is also a physical attribute and can be effectively used as a discriminator for geometrical shape classifications.

Instantaneous phase represents the phase of the resultant vector of individual simple harmonic motions. While individual vectors may rotate in clockwise motion, their resultant vector may at some instances form a cardioid pattern and appear to turn in the opposite direction. This is interpreted as the effect of interference of two closely arriving wavelets. This is also caused by noise interference in low amplitude zones. Because of these reversals, the instantaneous frequency has unusual magnitudes and fluctuations. Since instantaneous frequencies are influenced by the bed thickness, it is best to observe them without too much interference. This is accomplished by using several adjacent traces to form a consistent output. It has been shown that instantaneous frequency, computed as the time derivative of instantaneous phase, relates to the centroid of the power spectrum of the seismic wavelet.

Trace Envelope *E(t)* represents the total instantaneous energy of the complex trace independent of the phase and is computed as the modulus of the complex trace: *t* varies approximately between 0 and the maximum amplitude of the trace. The envelope relates directly to the acoustic impedance contrasts. It may represent the individual interface contrast or, more likely, the combined response of several interfaces, depending on the seismic bandwidth.

Dip of Maximum Similarity and ***Similarity*** are computed together, but stored independently. First the similarity (semblance) over user-indicated sliding time window is computed by scanning adjacent traces in a user-defined range of dips. Then the dip of maximum similarity is detected. Similarity values are continuously updated for each sample; therefore there is a dip and similarity value for each data sample. Dip of maximum similarity and similarity attributes are the basis for many of the hybrid attributes. This could be used to map structural discontinuities.

Example

Our example comes from the Boonsville area of North Central Texas. First, using information provided by the Bureau of Economic Geology in Austin, Texas, five horizons were delineated. These include the productive zones of the Bend Conglomerate as well as a horizon near the base of the conglomerate. The stratigraphic column will illustrate these zones (Fig 1)

Tool used for Advanced interpretation

All the work have been done on **SMT"S Kingdom 8.4 Advanced** Interpretation software.

THE KINGDOM SOFTWARE

SMT's Kingdom suite software is the global industry leader for Windows- based geophysical and geological interpretation software. SMT software enables intuitive interpretation, validation, risk reduction and data management, in one integrated executable. The benefit of truly integrated software, that is logical to learn and to use, has significantly improved interpreter productivity. SMT is headquartered in Houston, Texas with offices in Calgary, Croydon (UK), Moscow and Singapore.

TKS-2d/3dPak is Seismic Micro Technology's flagship, fully integrated Geophysical & Geological Interpretation software package. With 2d/3d Pak, interpreters can generate horizons and faults on in-lines, cross-lines, and arbitrary lines, as well as slices. These capabilities are functional in both Time and Depth domains. Horizons can be automatically tracked on vertical seismic displays and horizontal slice displays. Improved tracking algorithms for horizon interpretation are combined with user interpreted faults and fault polygons to produce seismic based interpretation maps.

Borehole and well log information can be displayed on seismic sections in time or depth. Geologic-based interpretation information is seamlessly integrated with seismic interpretations to produce a cross discipline, risk-reduced approach to oil and gas exploration. Formation tops interpreted in wells can be projected on vertical seismic displays then gridded and contoured over the project area.

To simplify workflow, projects can be managed and structured through a user-defined work tree to isolate and organize pertinent data objects into smaller more manageable subsets.

TKS-VuPak is a powerful, interactive, 3D interpretation and visualization application for geophysical and geological data that is fully integrated with the rest of the software.

Using the dynamic fault builder, geoscientists can quickly build 3D fault surfaces as they interpret fault segments. Horizon and geobody interpretation can be accomplished through SurfaceHunt (a true 3D horizon autopicking tool) and VolumeHunt (voxel picking in a rendered attribute volume). These algorithms offer a new level of interpretation capability.

Interpreters have control of opacity, color, and lighting of seismic volumes, horizons, faults, and grids. They can quickly scan data through slice animation, chair-cut, and oblique-slice displays. Furthermore, volume scanning using interpreted horizons and co-blending multiple attributes helps rapidly identify subsurface anomalies.

TKS-RSA gives users access to 50+ advanced 2D and 3D post-stack seismic attributes, including curvature, spectral decomposition and similarity (edge detection processing). This capability is fully integrated into SMT's KINGDOM family of products to create a time-efficient, cost-effective solution for optimizing reservoir assets and increasing well accuracy.

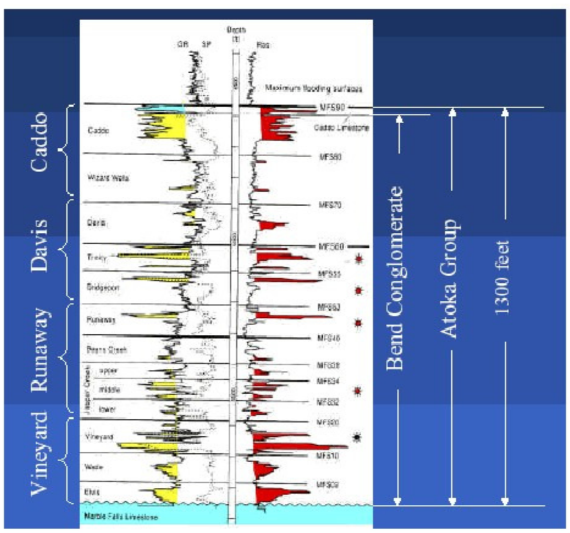

Fig1: BEG Stratigraphic Column of the Bend Conglomerate

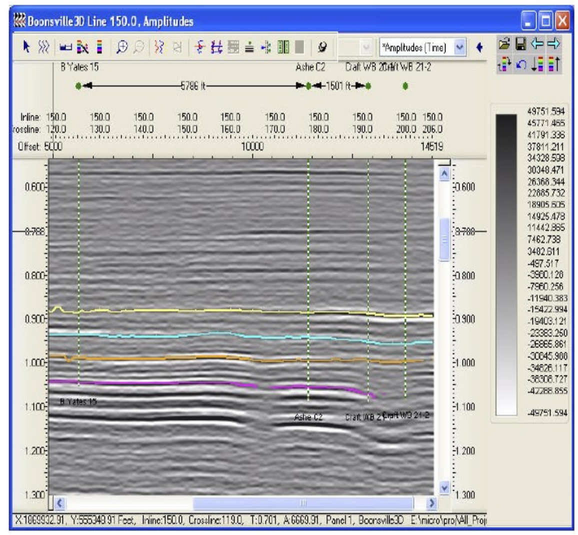

Figure 2: Boonsville ((Amplitudes of Line 150) The seismic section (Line 150 from about Trace 125 to 205) shows fairly continuous reflections from about 0.5 to 0.9 seconds. The deeper reflections show possible structural breaks indicated by the lowering of amplitude and sagging in seismic time.

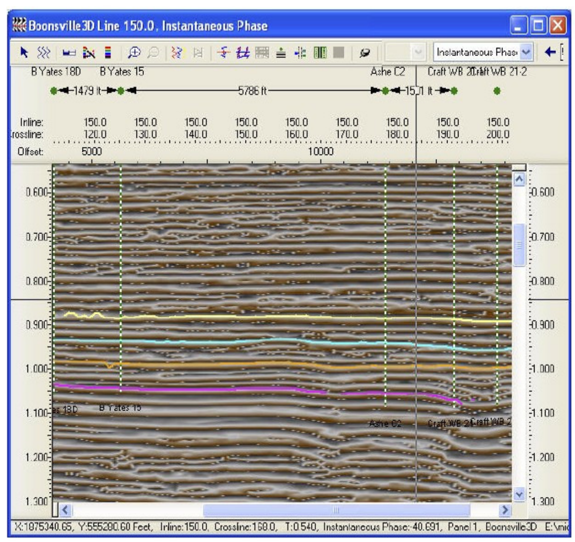

Fig3: Boonsville (Instantaneous Phase of Line 155) Each of the interpreted horizons basically tracks a constant phase value. Instantaneous Attribute can be used quickly and accurately to pick seismic events (or sequence boundaries) regardless of amplitude changes.

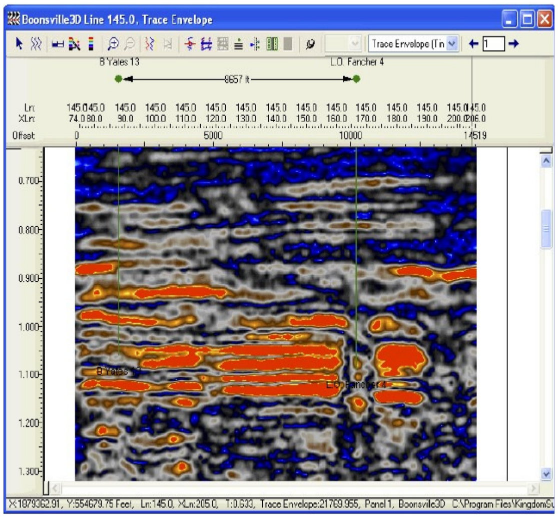

Fig4: Boonsville (Trace Envelope of Line 145) Notice the disruption in the horizontal continuity between Traces 164 and 172. This represents a karst feature caused by the dissolution of the underlying Ellenburger. This represents only one of many such features in the area.

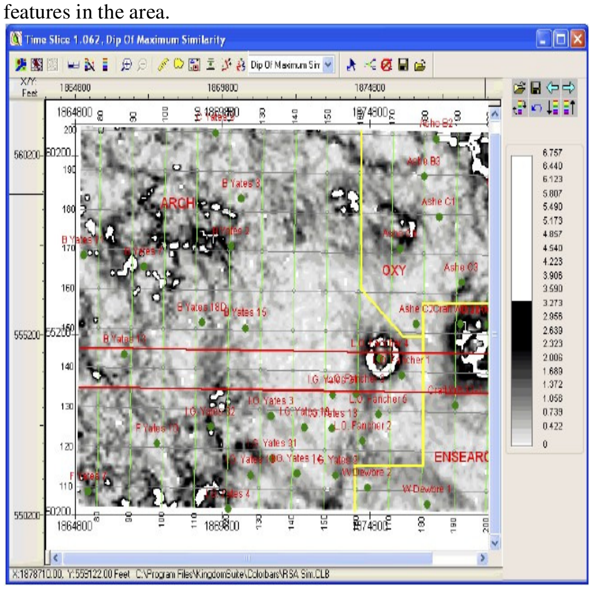

Fig: 5 Boonsville (Dip of Maximum Similarity)

At the time slice **1.062** while moving the cursor through the karst area on the vertical seismic section displaying the **Trace Envelope**, we noticed that the sharp edges of the anomaly shown in the **Dip of Maximum Similarity** time slice correspond with the Karst demarcation of the vertical seismic line

In order to delineate the edge of the Karst feature we analyzed, the edge of the anomaly was mapped as a fault. The time slices 1.040 and 1.060 and the vertical seismic section shows the Karst fault Interpretation.

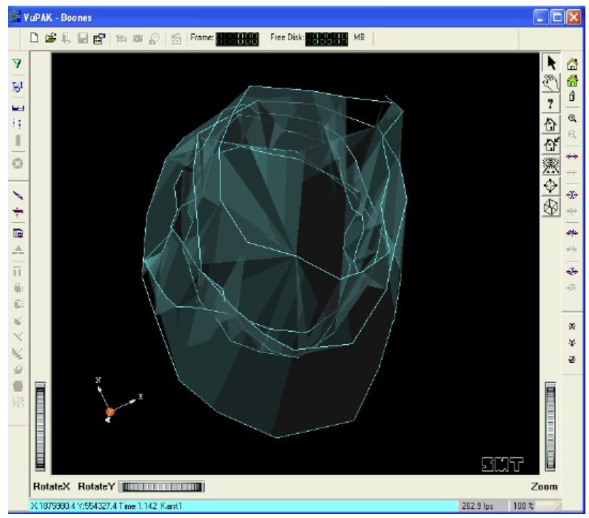

Fig 6: Karst fault display in 3 dimensional space. Time Interval is 0.8-1.3 seconds.

We now render the volume with **Kingdom’s VuPak 3D Interpretation tool** in order to visualize the Karst feature:

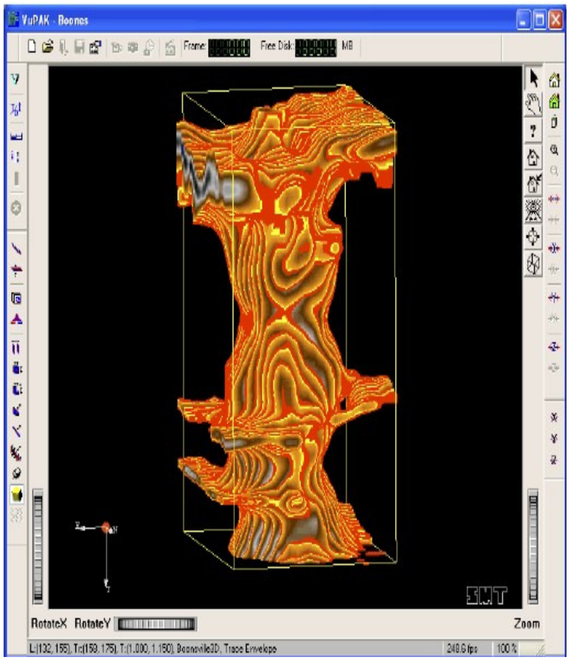

Figure 7: Karst Fault Outline (Boonsville)

Conclusions

This volume represents just one structural feature created by the dissolution of Carbonates in Ellenburger. The highs created between these solution features become one of the main traps of the Boonsville area. Some Karst features also trapped gas.

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