# Seismic Attribute and Spectral Decomposition Analysis of the Sooner Field

## An Overview of the Sooner Field

*Advanced Secondary Recovery Project for the Sooner "D" Sand Unit, Weld County Colorado Final Report by diversified Operating Corporation, November 1996*, states that the Sooner Unit has been interpreted to be a Cretaceous D Sand stratigraphic play, located in Weld County, northeastern Colorado. The reservoir is interpreted to be funnel-mouth estuary and valley fill. By correlating log data, the D Sand interval appears to be a series of vertically stacked channels with a maximum gross thickness of 70 feet. Commonly, the channels have a gross thickness of 30 feet or less.

The D Sand individual sands and valley fills have been very difficult to visualize using conventional amplitude data. The following workflow will employ a variety of seismic attributes, among them Spectral Decomposition (SD), to resolve this visualization problem.

### Seismic Resolution of the D Sand in 2d/3dPAK

Survey spectrum analysis has shown that the dominant frequency for the D Sand is approximately 55 Hz. with a vertical bed resolution (tuning) of approximately 61 feet ((13,500 ft/sec IVEL / 55Hz) / 4). Whereas, the tuning thickness chart for the Sooner Unit 1-21A illustrates a tuning time thickness of 8 to 9 ms. Therefore, tuning is calculated to be in the range of 55 to 60 feet. The D Sand is located seismically at approximately 1.45 sec. two-way time. Most of the D Sand pay thicknesses are between 30 to 70 feet gross. Therefore, essentially all the net pay in the wells is at or below tuning.

## Seismic Attribute Generation using Sooner3D

Seismic subvolumes were created for the Sooner3D survey using the following attributes over a time interval of 1.0 to 2.0 seconds:

- Dip of Maximum Similarity
- Instantaneous Dip
- Instantaneous Phase
- Relative Acoustic Impedance
- Trace Envelope

These seismic attributes were displayed at time slice 1.456 seconds.

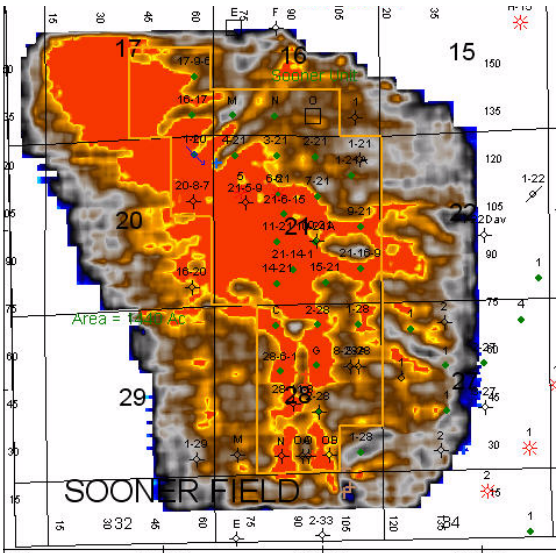


**Figure 1. Trace Envelope**

The Trace Envelope Attribute (Figure 1) best shows the overall shape of the D Sand represented by the orange color. None of the extracted seismic attributes displays the shape of the valley fill and estuary environment in detail.

# Spectral Decomposition of the Sooner Seismic Volume

The dominant frequency of the Sooner3D seismic volume is 55Hz. However, the fact that the valley fill architecture cannot be resolved the with the previously run seismic attributes may be due to the fact that the D Sandstone valley fills responding to different frequencies than the rest of the seismic. In other words, the valley fill tuning frequency may be either greater or less than the overall Sooner3D dominant frequency. Spectral Decomposition was run in order to analyze the frequencies of the Sooner3D seismic volume, observe the different bands and examine each band volume.

Spectral Decomposition was performed using Seismic Micro-Technology, Inc. KINGDOM Software and Rock Solid Attributes on a seismic interval from one to two seconds. The SD Envelope Sub-band Attributes were selected, and the defaults were applied for banding based on a linear scale.

## Display Spectral Decomposition in 3D Volumes

The best way to view the individual Spectral Decomposition volumes is with a 3D volume tool. For this study KINGDOM's VuPAK was used. The Envelope Sub-Band for 56 Hz (close to the overall dominant frequency for the Sooner3D seismic survey) at the level of the D Sand, approximately 1.456 seconds two way time was examined. However, it can be noted that very little in the way of detail is visible at this band width.

With the SD Envelope Sub-band for the 32Hz volume it is apparent that the 32 Hz bandwidth may be construed as the sandier portions of the volume, represented by the yellows and oranges, as shown in Figure 2.

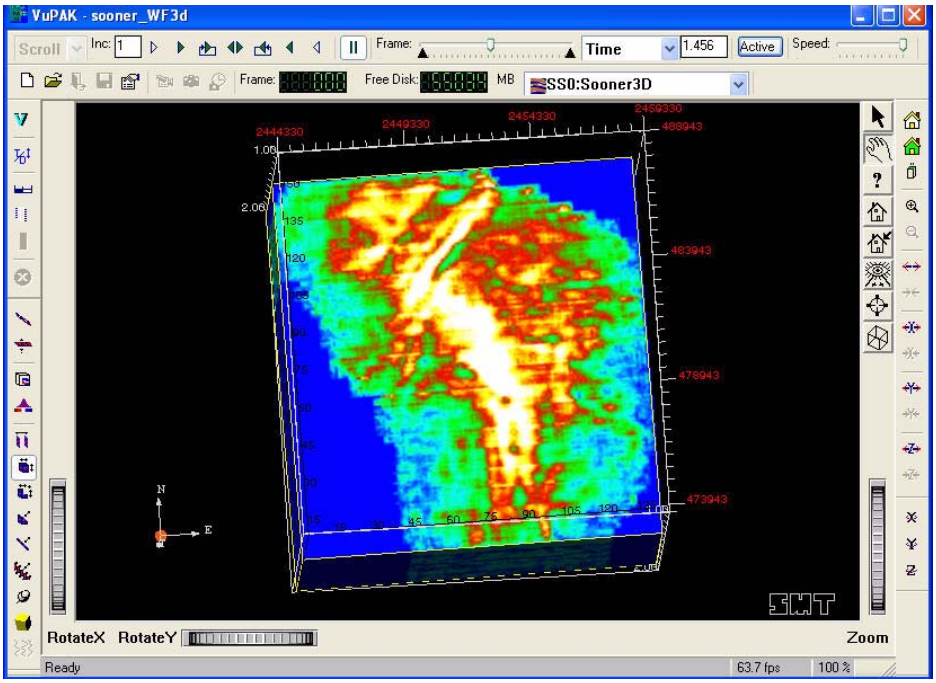


**Figure 2. SD Envelope Sub-band_32.0_8.00 at 1.456 seconds**

## Delineating the D Sand Valley Fill Complex

The SD Envelope Sub-band_32 Hz volume shows the gross depositional nature of the D Sands, but the fluvial valley fill complex is still not clearly defined. To define what is thought to be the valley fill architecture, the Rock Solid Attributes Geometric Attributes were run over the SD Envelope Sub-band_32 Hz volume. The full time range is not required as the D Sand reservoir is located between 1.4 and 1.6 seconds.

Geometrical attributes are calculated for each trace by scanning the adjacent traces and computing various characteristics defining event dip, continuity, etc. Geometric attributes respond to changes in reservoir structure and stratigraphy. They are the result of areal variations of physical attributes computed over user-defined time and distance gates.

Instantaneous Dip of the SD Envelope Sub-band_32 Hz volume gave the best presentation of what is believed to be the valley fill architecture. At 32 Hz, tuning is approximately 100 feet, which is thicker than the individual D Sand stacked channels. This bandwidth appears to be imaging the broader and thicker overall valley fill deposits. Opacity was clipped so that the assumed valley fill complex remains opaque and the rest of the volume becomes transparent. The results are displayed in Figure 3.

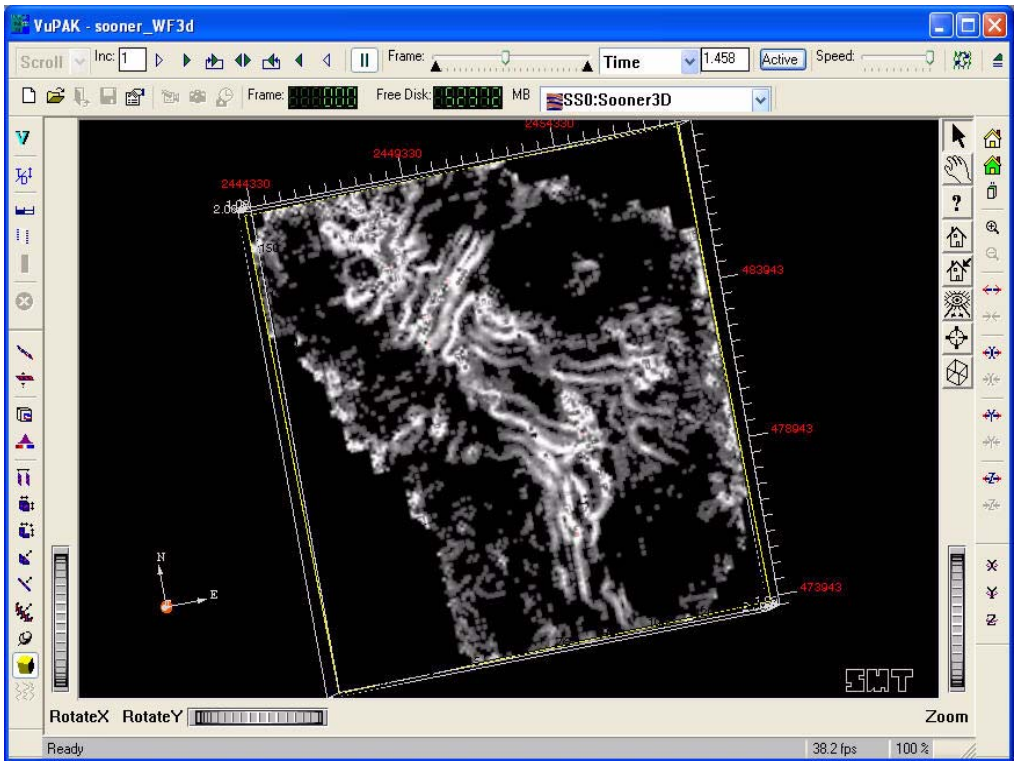


**Figure 3. Rendered valley fill complex**

# Further Delineation of the D Sand Valley Fill Complex

What is believed to be the D Sand valley fill sequence has been delineated at 1.456 seconds. Data type coblending was used to further refine the valley fill.

The results of coblending SD_Instantaneous Dip and SD_Shale Indicator can be viewed as shown in Figure 4. The bright colors are believed to be associated with the valley fill while the darker gray colors are indicative of shales.

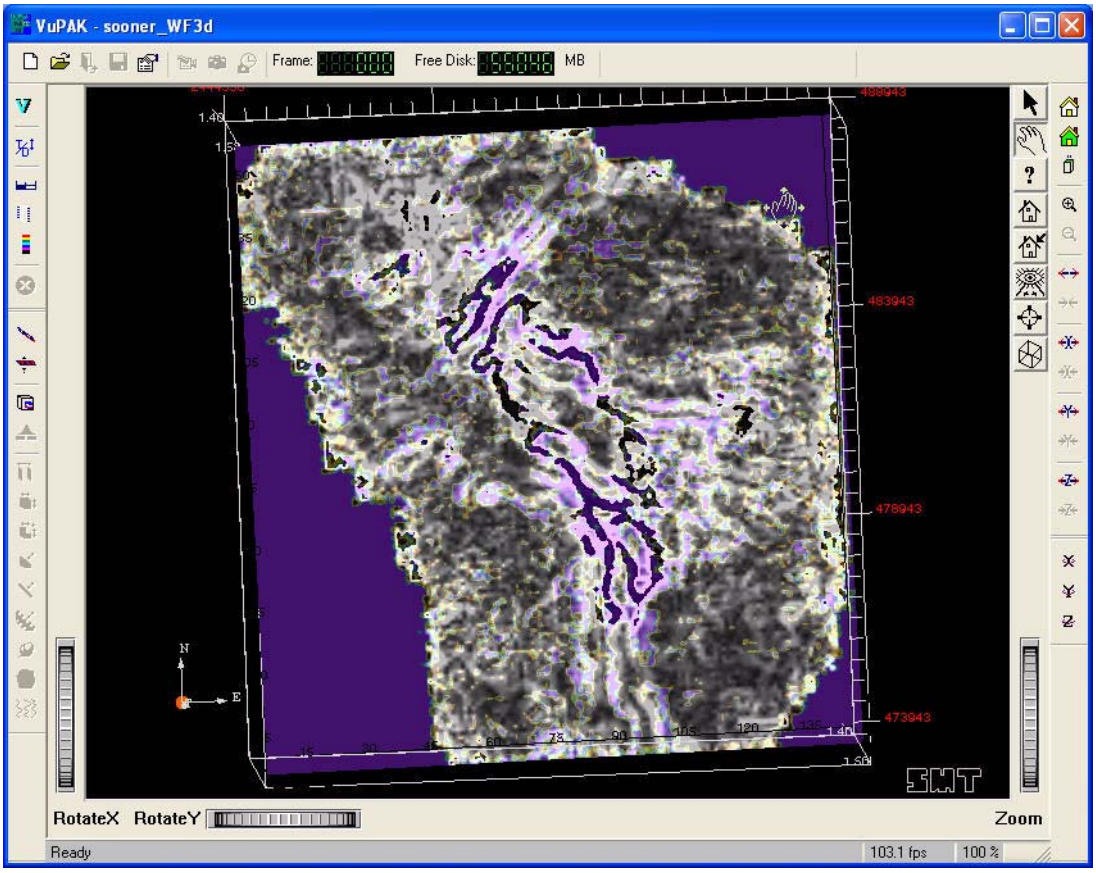


**Figure 4. Coblended time slice 1.456**

To determine if structure is influencing the imaging of the D Sand valley fill complex, one additional test was performed. The D Sand horizon was flattened. Instantaneous Dip was then projected onto the flattened D Sand horizon.

The complex appears to be very similar in both the flattened and unflattened D Sand time. Structure does not seem to play an important role in the deposition of the D Sands. Lastly, cross sections through wells at various locations within the field seem to correlate the sands visible in the wells to the seismic imaging of the proposed valley fill complex.

## Conclusions Based Upon Seismic Interpretation

Due to the fact that the thickness of the D Sands is right at or below the tuning thickness of the seismic data, conventional amplitude seismic interpretation is largely unsuccessful in delineating the reservoir. However, through the use of horizon attributes, various seismic attributes, and the spectral decomposition of the seismic volume, it is possible to visualize what may be the valley fill complexes of the D Sand reservoir.

## References

Advanced Secondary Recovery Project for the Sooner “D” Sand Unit, Weld County Colorado Final Report by Diversified Operating Corporation, November 1996

*Estuarine Facies and Valley Fills*, a presentation by Esther Eke, Doug Landgraf and Steven Burkhead

Sonnenberg, Stephen A., “Tectonic, Sedimentary, and Seismic Models for D Sandstone, Zenith Field Area, Denver Basin, Colorado” The American Association of Petroleum Geologists Bulletin, V. 71, No. 11 (November 1987), P. 1366-1377

Sandstone Depositional Environments, AAPG Memoir 31, Edited by Peter A. Scholle and Darwin Spearing.

The author would also like to thank Mr. Rocky Roden and Mr. Douglas Seyler for the contribution of their time and talents.