Conventional amplitude seismic interpretation may not delineate thin sands. 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 a reservoir in Colorado.

Visualizing Thin Sands by Adv

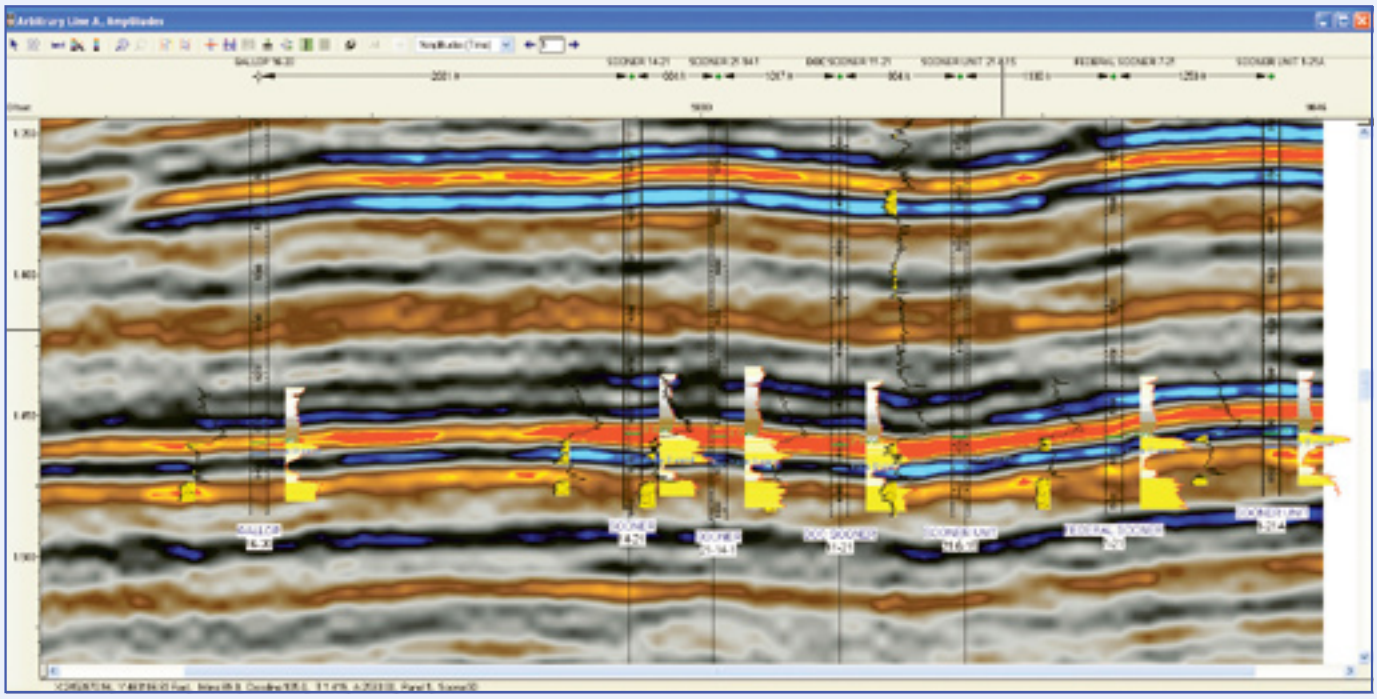
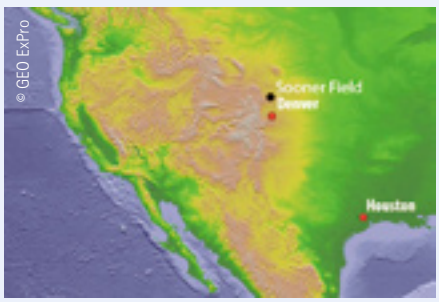


Figure 1 - SD Envelope Sub-band for the 56Hz volume



The Sooner Field is located in Weld county in northern Colorado.

An Overview of the Sooner Field

The Sooner Unit is a Cretaceous D Sand stratigraphic play, located in Weld County, Colorado. The reservoir is interpreted to be funnel-mouth estuary and valley fill. By correlating log data, the D Sand reservoir appears to be a series of vertically stacked channels with a maximum gross thickness of 70 feet (21m). Commonly, the channels have a gross thickness of 30 feet (9m) or less.

The D Sand individual sands and valley fill complexes have been very difficult to visualize using conventional seismic data because the reservoir is very thin. The following workflow will employ Spectral Decomposition (SD) to subdivide the seismic data into different bandwidths to resolve this visualization problem.

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

On a vertical seismic section, the D Sand is located at approximately 1.45 sec. two-way time. Spectrum analysis of the 3D seismic data volume has shown that the dominant frequency for the total 3D volume is 55Hz, with a vertical bed resolution (tuning) of approximately 61 feet (19m) ((13,500 ft/sec interval velocity / 55Hz) / 4). Log curve data has shown that the D Sand pay thicknesses are between 30 to 70 feet (9-21m) gross. Therefore, essentially all the net pay in the wells is at or below tuning and cannot be seen with conventional seismic data.

anced Seismic Interpretation

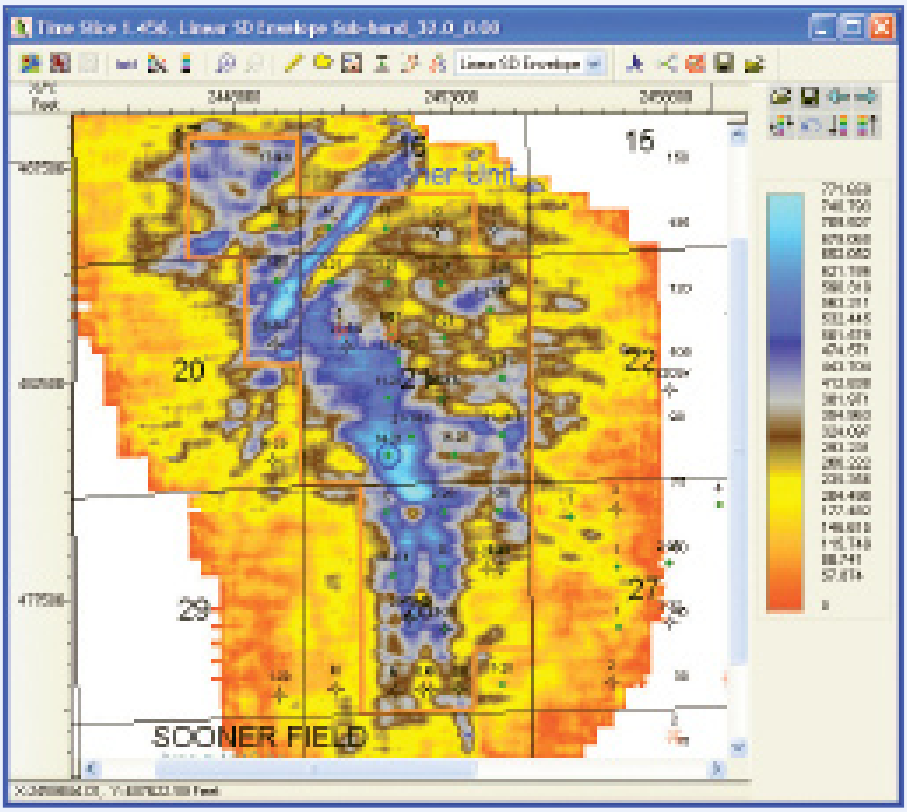


Figure 2 - The SD Envelope Sub-band_32 volume

Spectral Decomposition of the Sooner Seismic Volume

The dominant frequency of the Sooner3D seismic volume is 55 Hz. But the valley fill tuning frequency may be either greater or less than the overall seismic dominant frequency. Spectral Decomposition was run in order to analyze different frequencies of the 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 (RSA) on a seismic interval from one to two seconds. A linear scale was used to create equal sub-band volumes.

Display Spectral Decomposition in 3D Volumes

The best way to view the individual spectral decomposition volumes is with **KINGDOM's VuPAK 3D** interpretation tool. The sub-band for 56 Hz (close to the overall dominant frequency for the 3D seismic survey) at the level of the D Sand, approximately 1.456 seconds two way time, was examined. Little in the way of detail is visible at this band width as shown in Figure 1.

Upon examination of the sub-band for the 32Hz volume, the 32 Hz bandwidth may be construed as the sandier portions of the volume, Figure 2.

The KINGDOM Software

As oil and gas fields mature and new plays are discovered in remote terrain, geoscientific analysis has become increasingly sophisticated. The modern geoscientist must integrate geological data, multi-dimensional seismic, modeling and advanced analytics in a single interpretation.

But just because interpretation has become more complex doesn't mean your software has to be. Seismic Micro-Technology (SMT) allows the geoscientist to focus on the analysis, not on managing the tools.

Seismic Micro-Technology was founded in 1984 and developed the first geoscience interpretation tools for the Windows® environment. SMT has now office locations in Texas, UK and Singapore. The software is used by geoscientists in over 85 countries.

TKS - 2d/3dPAK

TKS - 2d/3dPAK is Seismic Micro-Technology's flagship, fully integrated geophysical and geological interpretation software package. With 2d/3dPAK, interpreters can generate horizons and faults on in-lines, cross-lines and arbitrary lines. Horizons can be automatically tracked with newly improved algorithms and combined with 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. Formation tops interpreted in wells can be projected on vertical seismic displays then gridded and contoured over the project area. This geologic-based interpretation information is seamlessly integrated with seismic interpretations to produce a cross discipline, risk-reduced approach to oil and gas exploration.

To simplify workflow, projects in 2d/3dPAK can be managed and structured through a user-defined work tree to isolate and organize pertinent data objects into smaller more manageable subsets. 2d/3dPAK also has a knowledge management tool called PAKnotes™ that helps you achieve a higher level of productivity by quickly connecting all of your interpretation thought processes into one collaborative environment. It instantly provides access to the thoughts and knowledge of others and improves direct communication from the workroom to the boardroom.

TKS - VuPAK

VuPAK is a powerful, interactive 3D interpretation and visualization package for geophysical and geological data that is fully integrated with The KINGDOM Software.

With the integration of geological and geophysical information in 3D space, TKS - VuPAK delivers a comprehensive suite of tools in the Windows environment to help geoscientists realize more accurate interpretations and higher productivity.

Interpretation in VuPAK is 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 over the opacity, color, and lighting of the seismic volumes, horizons, faults, and grids.

VuPAK provides a quick data scanning ability through slice animation, chair-cut, and oblique-slice displays. Subsets of a survey can be interactively selected from a base map, log curves with formation tops along vertical and deviated boreholescan be displayed, images can be rotated along any axis to demonstrate spatial relationships, and specific areas of interest may be viewed with various zoom capabilities.

TKS - RSA

TKS - Rock Solid Attributes (RSA) gives users access to 43 advanced 3D post-stack seismic attributes, including spectral decomposition and similarity (edge processing). RSA is fully integrated into SMT's KINGDOM® family of products.

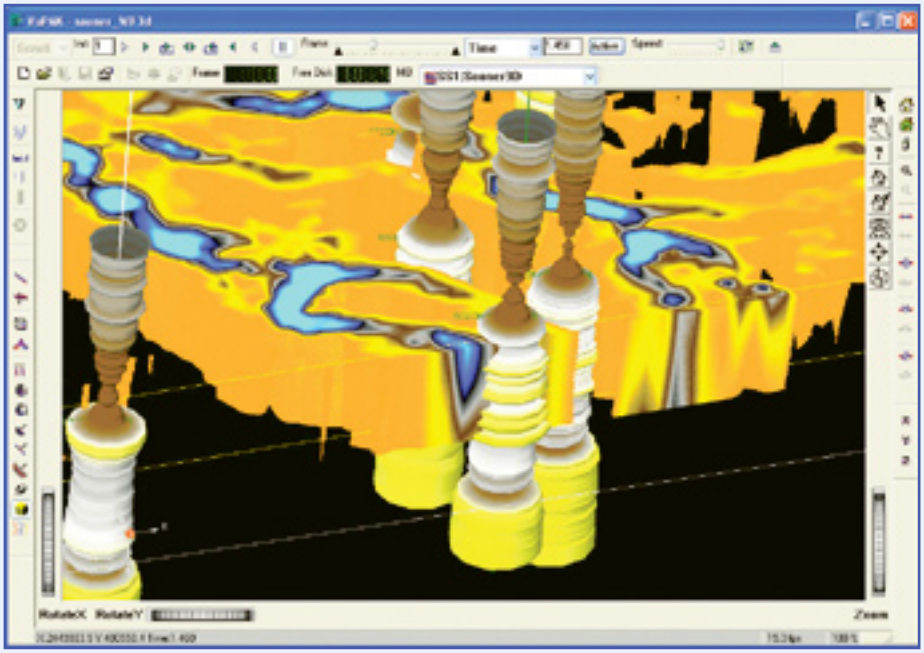


Figure 3 – Volume rendered Instantaneous Dip of the SD Envelope Sub-band_32 volume

Delineating the D Sand Valley Fill Complex

The sub-band_32 volume shows the gross depositional nature of the D Sands, but the fluvial valley fill complex is still not clearly defined. To define what may be the valley fill architecture; **RSA Geometric Attributes** were run over the sub-band_32 volume 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 sub-band_32 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 as shown in Figure 3.

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. VuPAK coblending of Instantaneous Dip and Shale Indicator was used to further refine the valley fill.

To determine if structure is influencing the imaging of the D Sand valley fill complex, the D Sand horizon was flattened. 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 field wells seem to correlate the sands visible in the wells to the seismic imaging of the proposed valley fill complex.

Conclusions Based Upon Seismic Interpretation

The thickness of the D Sand reservoir 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.

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