Identification of Deltaic Facies with 3-D Seismic Coherency and the Spectral Decomposition Cube: A Study From South Marsh Island Area, Gulf of Mexico

by John A. Lopez, Greg Partyka, Norm L. Haskell , and Susan E. Nissen, Amoco, New Orleans, Louisiana and Tulsa, Oklahoma

A new technique called the spectral decomposition cube is useful for mapping stratigraphy or reservoir delineation. The spectral decomposition cube is a Fourier transform applied to individual traces within a window around an interpreted horizon. Examination of the amplitude maps of specific frequencies can accentuate geologic features that are "tuned" to specific frequencies. Regional 3-D seismic in the Gulf of Mexico will be shown to illustrate detailed deltaic stratigraphic patterns. The potential usefulness of these frequency defined map attributes is demonstrated by mapping of a series of shallow horizons on a speculative seismic survey in the South Marsh Island area of the offshore Louisiana, Gulf of Mexico.

Coherence maps derived from 3-D seismic are a major breakthrough in the effective interpretation of 3-D seismic data. Coherence is defined as "a quantitative measure of the similarity or dissimilarity of nearby seismic traces" and is typically calculated as a post-processing seismic attribute. Coherence algorithms and spectral decomposition cubes are attributes of a rapidly developing expanding family of seismic attributes that are particularly helpful for 3-D seismic interpretation of map-view patterns of faults or stratigraphy. Their usefulness is increased when used in combination with traditional mapping techniques.

The result is a continuous measure of lateral changes in the seismic wavelet within the analysis window. The sinusoidal character of the seismic wavelet is removed, and what remains is principally geologic. Therefore, coherence can be used to map structural and sedimentological features directly. A major benefit to using 3-D coherence is that it can be run without any prior interpretation, thus removing initial interpretation biases and increasing the speed of subsequent interpretations. It is important to note that other seismic interpretation products, such as edge detection, may look similar to coherence, but these attributes may require a well-mapped horizon prior to calculation. Overall coherence seems to be more useful for structural applications. The spectral decomposition technique was developed to address the need for improved automated stratigraphic mapping.

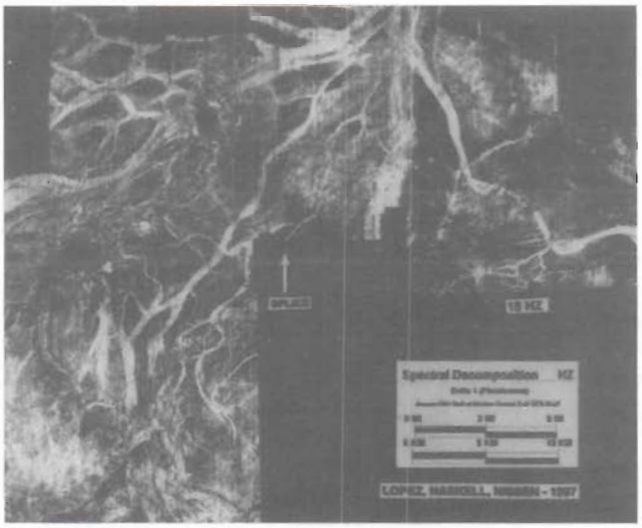

Figure 1. *Spectral Decomposition Cube image of a Pleistocene subsurface delta, South Marsh Island*

The spectral decomposition cube can supersede coherence mapping when used for stratigraphic detection. The spectral decomposition amplitude maps are more useful for detecting stratigraphic features than the phase maps. The spectral decomposition cube is created by applying a FFT (Fast Fourier Transform) to the windowed trace at the picked horizon. The FFT decomposes the trace into all the separate frequencies of appropriate amplitude and phase which when summed together would re-create the initial windowed trace. The resulting spectral decomposition data is treated as either amplitude or phase cubes in which each cube has two dimensions that are a plane view map and the third dimension that is frequency increments. Scrolling up or down through the spectral decomposition cube allows examination in plane view of either amplitude or phase of each frequency within the trace decomposition. The aim is to accentuate possible stratigraphic features that may be tuned to specific frequencies and are not evident in the initial composite trace. Therefore these data are sometimes referred to as the spectral decomposition tuning cube.

One example is a coherency time slice corresponding to a Pleistocene surface at approximately 1200 m (4000 ft) depth, which displays a complex system of deltaic channels. The nearly identical map of channels can be seen on the spectral decomposition cube at 18 Hz. However, on the spectral decomposition image additional subtle features are seen that help complete the stratigraphic interpretation. A comparison of Pleistocene channel geometry with the modern Mississippi Delta suggests the presence of a paleo-Mississippi trunk channel oriented north-south and its associated distributary channels.

¶

Conclusions

Seismic attributes applied to modern 3-D seismic surveys can be used to study ancient depositional systems in remarkable detail. Coherence and spectral decomposition are relatively new seismic attributes that are particularly useful in identifying channels. In general, no single attribute should be considered superior to any other. Different attributes may reveal different elements of the stratigraphy or different geophysical manifestations of the stratigraphy. Spectral decomposition in particular requires reviewing of many

images to obtain all the possible information the seismic may hold. Final interpretations should include a composite of geologic information interpreted from many different images. The process is similar to that of satellite image interpretations of multiple-bandwidth images.

• Coherence is a multi-trace calculation that is a measure of the relative lateral variation in the traces. Spectral decomposition is a single trace calculation that decomposes the trace into a range of discrete frequencies, amplitude and phase. Spectral decomposition is a new way to map stratigraphic patterns which otherwise may not be recognized in the wavelet.

• 3-D seismic coherence and spectral decomposition are powerful seismic attributes to detect subsurface stratigraphy. These attributes are most useful when viewed in map view, where stratigraphic and structural patterns may be more evident.

• Channels in the South Marsh Island area generally appear as subparallel traces of low coherence at the channel margins.

• Different frequency amplitude maps reveal slightly different stratigraphic information which together give a more complete interpretation.

• Some stratigraphic "imprints" from shallower horizons can be found at certain frequencies from the spectral decomposition cube.

Please make reservations by Monday, January 26th
The reservation code is 5-0-5.