Paper 4

Spectral decomposition: extending the limits of seismic resolution for reservoir delineation

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Spectral decomposition is a seismic processing technique that has only recently been adapted for use directly in 3-D seismic data interpretation and reservoir imaging workflows. This technique has the potential to generate greater resolution of reservoir boundaries, heterogeneities and bed thickness than traditional broadband seismic displays and attribute extractions.

Spectral decomposition is used to identify thin beds through analysis of the frequency spectrum in a short window around the time of the bed. A thin bed spectral interference pattern is imposed by the distribution of acoustic properties within the short analysis window. In this example, a simple homogeneous thin bed introduces a predictable and periodic sequence of notches into the amplitude spectrum of the composite reflection.

Spectral decomposition can be used qualitatively, to reveal stratigraphic, structural edges and bodies, and relative thickening or thinning; and quantitatively, to give an accurate prediction of reservoir thickness or intra-reservoir travel time.

Interpretive processing using spectral decomposition has been applied to: delineation of facies/stratigraphic settings (such as flood plane boundaries, reef boundaries, channel sands, incised valley-fill sands, and other thin beds); resolving the order of deposition and migration routes; mapping detailed structural settings involving complex fault systems (such as reservoir compartmentalization); mapping near-surface environmental hazards (such as expulsion features and other near surface instabilities); and assisting reservoir modeling (mapping fluid changes, pressure changes and changes in 4D surveys).

The spectral decomposition interpretive processing workflows were developed at Amoco and first described by Partyka *et al.* (1999). There the authors describe two key processing and interpretation workflows: the "tuning cube", and "discrete frequency energy cubes" (also called "volume reconnaissance"). Additional enhancements to these workflows have since been devised, in both the seismic processing and the subsequent interpretation. Apache also has several patented and patent-pending enhancements for spectral decomposition processing.

Spectral decomposition is applied to conventional post-stack 3-D seismic data. It is generally preferable (as for most attribute analysis work) to have the seismic data processed for true amplitude recovery. Ideally, no band pass filtering, surface-consistent, migrated and output is either in 16-bit or 32-bit format. The sample rate should also be kept to a minimum. However, any moderately clean 3-D dataset can be used to investigate the potential of spectral decomposition and evaluate whether reprocessing of the seismic data is necessary. Ray trace modeling may be used in more complex terrains to determine whether any information might be found in the data.

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