HampsonRussell
Attributes

Advanced seismic attributes

The **Attributes** package is designed to create and extract a collection of advanced single- and multi-trace seismic attributes to enhance your interpreting ability to quantify the reservoir properties in seismic volumes. You can alsouse these tools for data preconditioning such as noise reduction and data quality control. Individual attributes provide information about the reservoir for you to use in the **HampsonRussell** geostatistical multi-attribute analysis programs, **Emerge** and **MapPredict.**

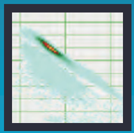
Benefits of Attributes include:

- Ability to extract and display subtle features within seismic data, such as fault discontinuities, structural curvatures and frequency content
- A comprehensive collection of new advanced industry- standard multi-trace algorithms
- Seamless integration with other tools in HampsonRussell allows easy data input, display and further analysis in other modules such as **Emerge** and **MapPredict**
- Use of multi-threading to greatly enhance computational efficiency

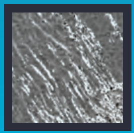
The computed attributes in **HampsonRussell** include a variety of curvature attributes, phase congruency and energy ratio attributes. A comprehensive set of tools is provided to perform spectral decomposition.

The **Attributes** package also contains a complete range of multi-trace edge-preserving filters, such as the Kuwahara and alpha trimmed mean filters for optimal pre-conditioning of seismic data.

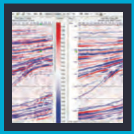
Additional single-trace attributes such as instantaneous envelope, phase and frequency, trace integration and differencing, and frequency slices are available in other parts of the **HampsonRussell** suite of programs.



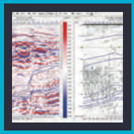
Bandwidth Attribute



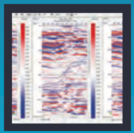
Curvature Attributes:
- Instantaneous Curvature
- Volume Curvature



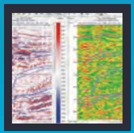
Edge Enhancement Attributes



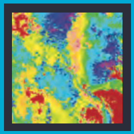
Energy Ratio Attributes



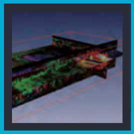
Multi-trace Filters:
- Anistoropic diffusion filter
- Edge-preserving filter
- 3D Gaussian smoothing filter



Phase Congruency



Single-trace Seismic Attributes:
- Instantaneous attributes
- Derivative and integrated attributes
- Filter slices, etc.



Spectral Decomposition:
- Empirical mode decomposition
- Short-time fourier transform
- Wavelet transform

GeoSoftware™

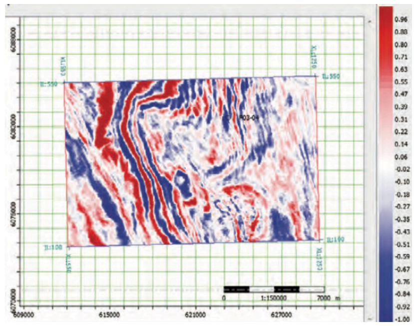
Curvature

Curvature can detect fractures, faults and other discontinuous features in seismic volumes. The instantaneous curvature and volume curvature algorithms are included. Instantaneous curvature calculates spatial frequencies, while volume curvature is based on computing the small time shifts within the volume.

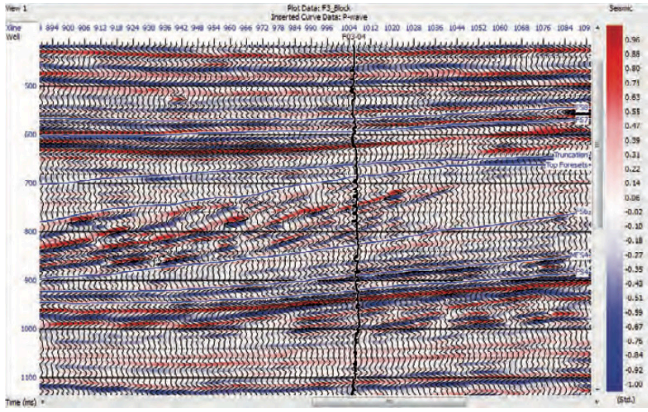
Other curvature attributes include:

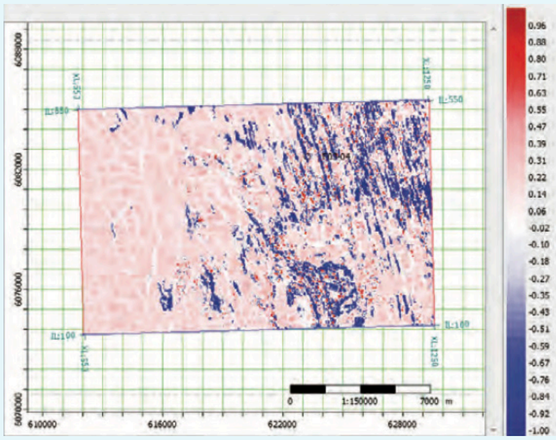
- $K_m = (K_{max} + K_{min})/2$, mean curvature
- $K_g = K_{ma}K_{min}$, Gaussian curvature
- $K_{postive}$ and $K_{negative}$ the most positive and negative curvatures
- K_c contour curvature, the curvature of the map contours along the surface
- K_d dip curvature, curvature in dip direction
- K_s strike curvature, curvature in strike direction
- K_n curvedness, the magnitude of the curvature independent of shape

Associated with the dip and strike curvature attributes, the dip and azimuth angles can also be computed.*

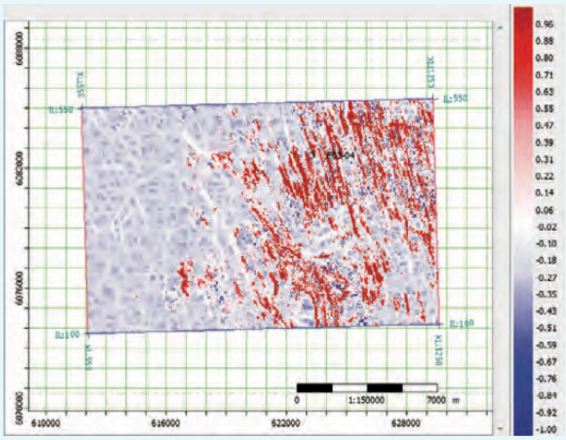


Example data set: *the figure on the left shows an amplitude time slice at 1000ms over the seismic volume and the figure below shows inline 442 from the volume.*





K_{min} attribute: *computed on a 1000ms time slice.*



K_{max} attribute: *computed on a 1000ms time slice.*

HampsonRussell Attributes

Phase Congruency

The phase congruency algorithm, developed by Kovesi (1996), was intially used in robot vision to detect edges. The fundamental idea behind this algorithm is to find the point at which the phase of the various frequency components in a data set are equal, or congruent.

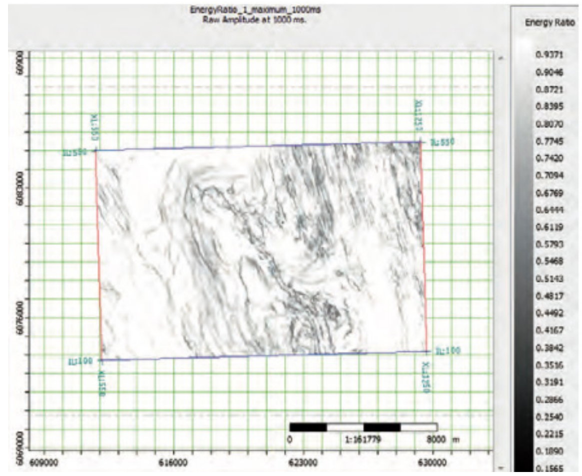
This can be visualized most easily in 1D Fourier analysis, but it is more rigorously done in this approach using a 2D Fourier analysis.

The key steps within phase congruency are:

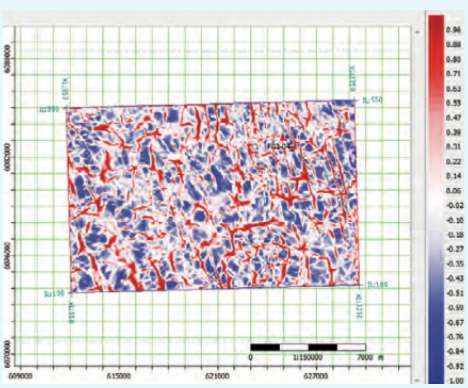
1. Transform the time slices to the 2D frequency domain

2. Perform frequency portioning using a combination of radial and angular filters

3. Transform back to time and map the 2D phase components using moment analysis



The 1000 ms time slice of the energy ratio attribute with the faults clearly shown.



The phase congruency attribute applied to the time slice at 1000 ms. Note the definition of the discontinuities highlighted by this attribute.

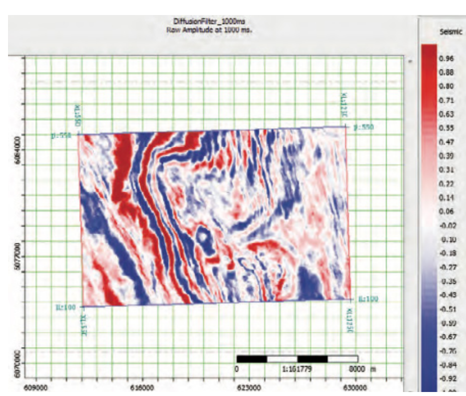
Energy Ratio

The energy ratio attribute provides an alternative way of revealing geological discontinuities such as faults on the seismic volumes. Like phase congruency it can reveal subtle fractures. It is computed as follows:

- Define a moving sub-volume within the main seismic volume
- Filter each sub-volume to remove steeply-dipping coherent events
- Compute the energy over both the unfiltered and filtered sub-volumes
- Find the ratio of the filtered volume energy to the unfiltered volume energy
- Copy this value to the center of the sub-volume and move to the next sub-volume

Anisotropic Diffusion Filter (ADF)

ADF is a type of pre-conditioning filter that can be applied to your data before computing volume attributes. Fehmers and Höcker (2002) refer to this attribute as a structure- oriented filter. ADF removes the noise by applying a smoothing operation parallel to the seismic reflections, therefore emphasizing the main geological and structural features of the data. The edge-detecting option of the algorithm would detect and keep the fault information in the 3D seismic data.



The results of the anisotropic diffusion filter with the edge detection option for the 1000 ms time slice.

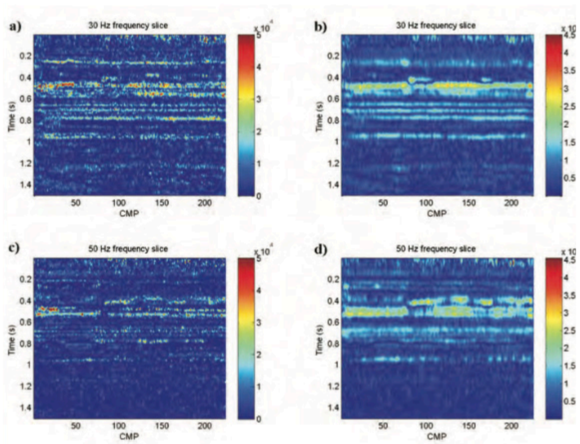
HampsonRussell Attributes

Spectral Decomposition

The **HampsonRussell Attributes** package provides a variety of frequency attributes for spectral analysis, from standard instantaneous frequency attributes, widely used short-time Fourier transforms and wavelet transforms to advanced empirical mode decomposition methods.

The empirical mode decomposition (EMD) algorithm is a technique which has been found to give better results than the instantaneous frequency, short-time Fourier transform (STFT) and wavelet transform, which are currently in use within our industry for time-frequency analysis. The EMD algorithm decomposes the seismic data into a series of intrinsic mode functions (IMFs), which in turn can be interpreted as the localized frequency content that we wish

to visualize. Limitations in the EMD algorithm inspired the addition of two more advanced forms of EMD which are Ensemble Empirical Model Decomposition (EEMD) and Complete Ensemble Empirical Mode Decomposition (CEEMD). Both of the methods EEMD and CEEMD improve and stabilize the original EMD algorithm.



Example data set: *Constant-frequency slice results from constant-frequency slices. (a) 30-Hz CEEMD-based method, (b) 30 Hz short-time Fourier transform, (c) 50-Hz CEEMD-based method, (d) 50-Hz short-time Fourier transform. The instantaneous spectrum combined with CEEMD shows higher time-frequency resolution than the short-time Fourier transform.*

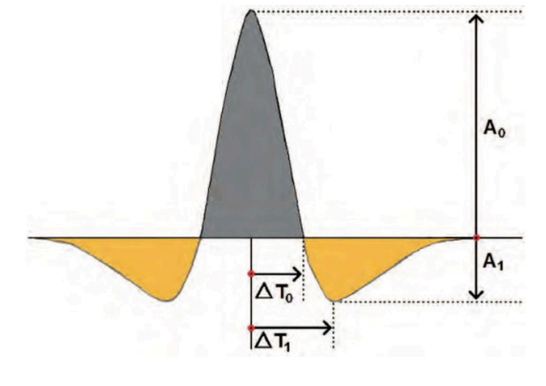
Bandwidth Attribute

The basic requirement for reservoir characterization is that the data are processed in such a way to ensure that the underlying propagating wavelet has near-constant properties (amplitude, phase and frequency). To monitor the wavelet characteristics, seismic bandwidth is a key parameter of seismic quality and interpretability (Araman and Paternoster, 2014).

The bandwidth index attribute measures the bandwidth of the wavelet from the autocorrelation of the seismic which in turn approximates the autocorrelation of the wavelet. The attribute calculates two ratios which are subsequently analyzed.

The first ratio (ΔT1/ΔT0) is the time distance ΔT1 between

the main peak and the first trough of the autocorrelation function; and time distance ΔT0 between the main peak and the first zero-crossing ratio. The second ratio is the peak-to- trough magnitude ratio of the autocorrelation function (A1/ A0) (see figure below). This measurement is independent of absolute amplitudes and frequency values and is characteristic of the shape of the signal. Broadband signals are located in the lower-left corner of the (ΔT1/ΔT0; A1/A0) cross-plot, while narrowband signals are located in the upper-right corner of this space (Araman et al, 2012).



TO LEARN MORE, VISIT:
www.GeoSoftware.com

CONTACT US AT:
info@geosoftware.com

GeoSoftware™