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Technical Update: TU-09-01
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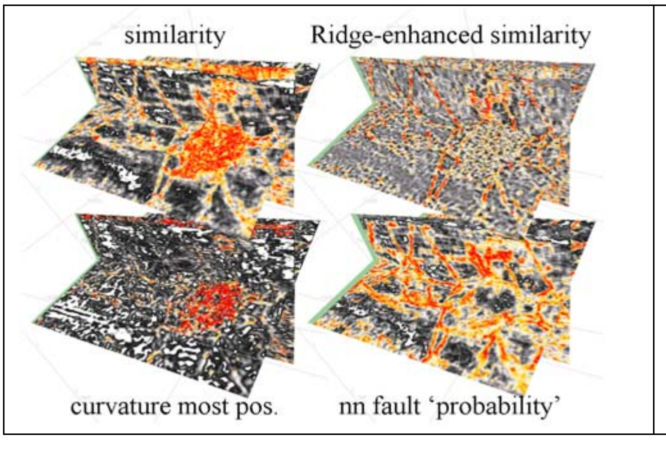
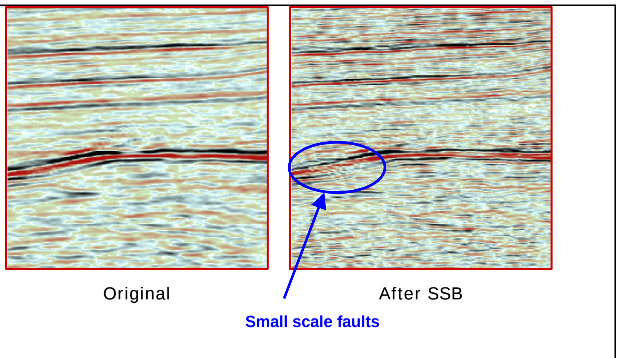
Subject: Faults and Fractures

This Technical Update describes various techniques developed by dGB for detecting faults and fractures in seismic data. Apart from Seismic Spectral Blueing all post-stack techniques are performed in OpendTect (+ plugins) and can be carried out by anyone with access to the software. The pre-stack technique is not available in OpendTect. This azimuthal AVA technique is offered by dGB as a bureau service only. The Table gives an overview of the main techniques used by dGB for fault and fracture analysis.

DOMAIN	TYPE OF PROCESS	NAME PROCESS / OUTPUT
Post-stack		
	Filter input data	Dip-steered median filter
	Filter input data	Seismic Spectral Blueing
	Attribute	Similarity
	Attribute	Curvature
	Neural network	Fault Cube
	Spectral Decomposition	Frequency component
	Filter output data	Ridge-enhancement
	Fault seal analysis	Chimney Cube + Fault Cube
Pre-stack		
	Azimuthal AVA	Fracture density & orientation

OpendTect supports various filters and attribute processing techniques for highlighting faults and fractures. Which technique to use depends on a study's objectives. The figure below left shows a comparison of 4 techniques: (dip-steered) similarity, most positive curvature, ridge-enhanced similarity and the Fault Cube. On the right a Seismic Spectral Blueing (SSB) result is shown.





Filtering the input data is often a good start for optimizing fault detection. The **dip-steered median filter** is an edge-preserving noise reduction filter. The filter is applied along the pre-calculated dip-azimuth of the seismic data. You need access to dip-steering plugin to apply this technique. **Seismic Spectral Blueing** is BP technology aimed at restoring high frequencies in 2D/3D reflectivity data, without boosting noise to unacceptable levels. The process shapes the seismic spectrum to be consistent with the earth's reflectivity as observed in measured acoustic well logs. Generally this improves seismic interpretability and helps to detect smaller scale faults. The software from ARK CLS will be available as OpendTect plugin shortly.

Similarity is a coherency-type of attribute that is supported in OpendTect Base (the open source part of the system). With dip-steering plugin installed the trace segments that go into the attribute calculation process can be extracted along the same seismic event, which improves the accuracy in dipping environments. Similarity is an ideal attribute for fast delineation of large-scale faults. For more detailed fault and fracture detection we often revert to **Curvature** attributes. These attributes are measures of the curvedness of a mapped surface. In OpendTect a whole set of curvature attributes is implemented. To calculate curvature at every sample position (as is done in OpendTect) we automatically construct a local virtual horizon at each evaluation point from the pre-calculated local dip- azimuth information (in OpendTect terminology: the steering cube). This implies that access to dip-steering plugin is a requirement for calculating curvature.

The **Fault Cube** is a multi-attribute, neural network object detection technique that calculates the 'probability' of a fault occurrence at every sample position. The user manually picks to sets of representative locations: faults and non-faults. At these locations several (typically 10-15) fault related attributes are extracted to train the neural network. The Fault Cube is primarily used for detecting large-scale faults. The Fault Cube generally exhibits better fault continuity than can be obtained with single attributes such as similarity and curvature.

Ridge-enhancement filtering is a data-driven, directional filtering technique that can be applied to any type of fault image cube (similarity, curvature, Fault Cube) for sharpening fault images. Ridge-enhancement is implemented as a default attribute set in OpendTect Base.

Spectral Decomposition is normally applied to seismic input data to analyze seismic data at different scale levels. This mode can also be used for fault analysis but Spectral Decomposition can also be applied in the following ways: a) to compute input attributes for a neural network to create a Fault Cube and b) to analyze fault image cubes at different scale levels. Spectral Decomposition is part of OpendTect Base. Both Fourier Transforms and Continuous Wavelet Transforms are supported.

Fault seal analysis is a unique dGB technique in which **Chimney Cube** images and fault images are visualized simultaneously. Leaking faults are detected by the activity observed in the Chimney Cube.

In the **pre-stack azimuthal AVA** technique "intercept and gradient" are calculated in different azimuthal directions. The residual errors are then used to construct an ellipse from which two new attributes are computed: eccentricity and orientation. Eccentricity is a measure of fracture density whilst orientation indicates fracture direction. This technique is applied along a mapped horizon. In theory it can also be applied at every sample position, in which case it generates 3D output. Azimuthal AVA requires special acquisition and processing: you have to acquire many azimuth-offset pairs in each bin and process the data in different angles. dGB, through an alliance with REXIMseis, offers pre-stack processing for AVA analysis at very competitive prices.

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