dGB Earth Sciences

Introduction to the SteeringCube

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Outline

- Introduction
  - Definition
  - Algorithms
- Applications

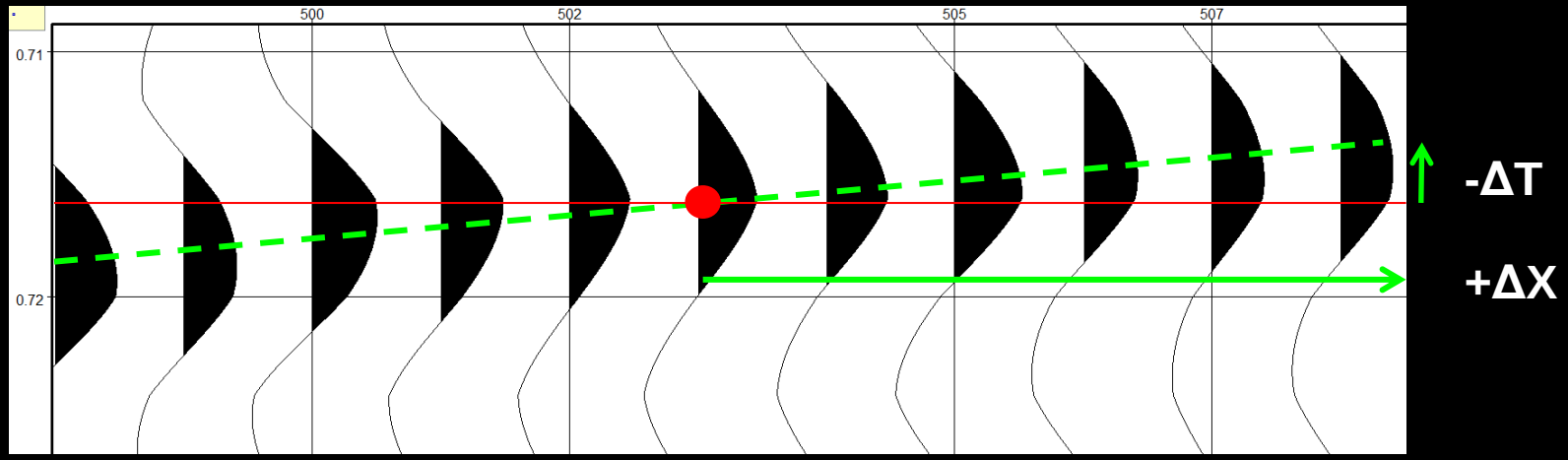
Definition

- A SteeringCube is a volume that stores information about the seismic dip at every sample position.

- SteeringCubes can be computed for 2D and 3D seismic:
  - A 3D SteeringCube stores: inline dip and cross-line dip
  - A 2D SteeringCube stores: the dip along the line direction.

Seismic dip

Seismic dip = ΔT / ΔX measured along the line direction in µs/m or mm/m.



The dip of this seismic event is represented by a negative number in the SteeringCube

Geologic vs. Seismic dip

Seismic dip (green) is a smoothed composite of geologic dips (yellow)

Image Courtesy: Ashton Embry

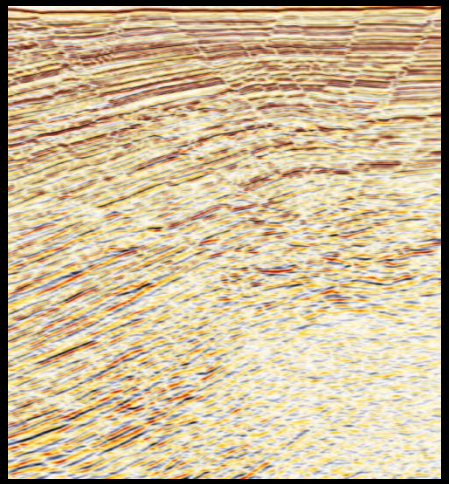
SteeringCube Algorithms

- BG Fast Algorithm
  - Computes dip from the gradient of the unwrapped instantaneous phase
  - Fast but noisy; requires smoothing

- FFT: standard, precise, combined
  - Computes dip from max. amplitude in 3D Fourier transformed domain
  - Precise extends Fourier input by padding zeros; improves accuracy at the expense of speed
  - Combined uses precise when standard is unstable

- Event
  - Computes dip between similar events (maxima and minima)

SteeringCube Types

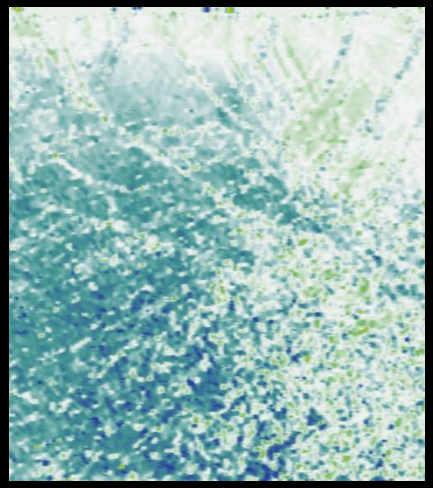


Input Stack

Two types:
Detailed and
Background

Raw Steering
(BG algorithm)

Contains many ***noise spikes and bands of noise*** *around low amplitude levels & zero crossings*



Detailed Steering
(mild smoothing)

Noise removed. Remaining are ***details*** *such as dip associated with fault drag.*

Background Steering
(heavy smoothing)

Noise removed. Details removed. Remaining is **structural dip**.

Detailed vs. background

Detailed Steering

- Contains information about:
  - Faults
  - Flexures
  - Stratigraphic features
- Use:
  - As attribute (e.g. polar dip, curvature): if detail should be emphasized
  - As steering when detail must be preserved (e.g. similarity)

Background Steering

- Contains information about:
  - Primarily background structure
- Use:
  - As attribute (e.g. polar dip, curvature): if overall structure should be emphasized
  - As steering for filtering and multi-trace attributes (e.g. median filter, similarity, …)

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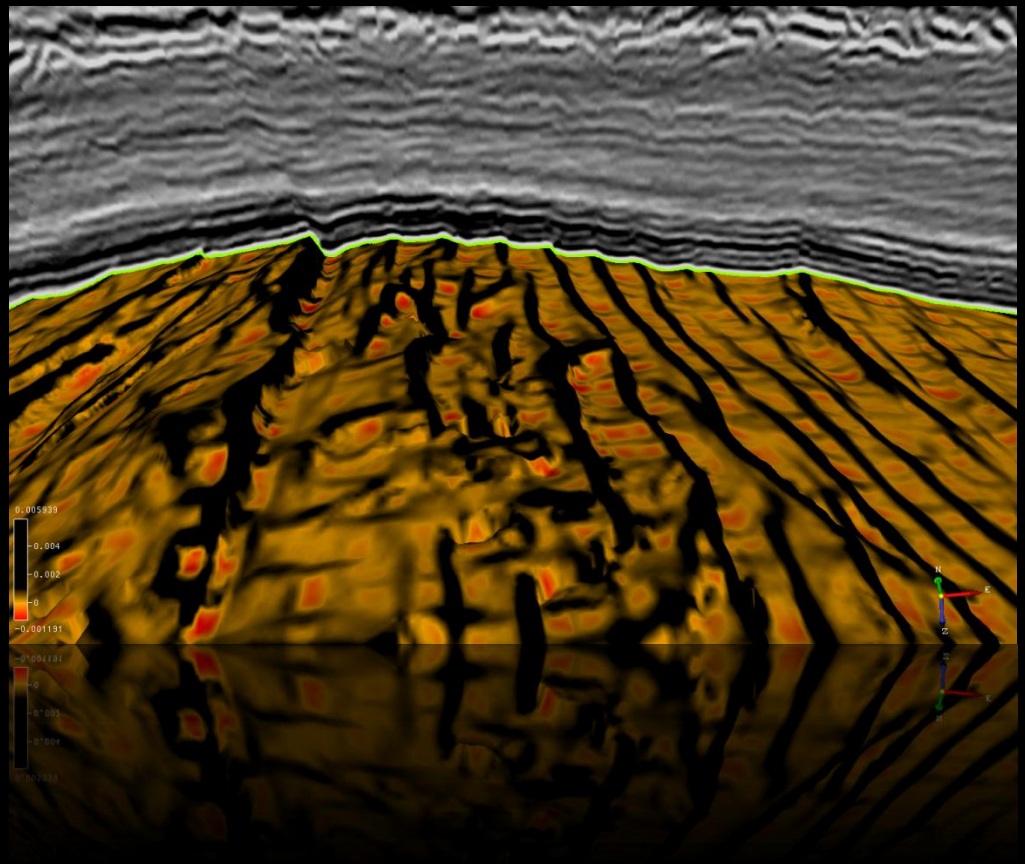
SteeringCube Applications

- Direct Attributes
  - Volume Curvature, Polar Dip, Azimuth, …
- Dip-Steered multi-trace attributes
  - Similarity, Texture, …
- Dip-Steered Filtering
  - Median, Diffusion, Fault Enhancement, …
- Horizon tracking
  - Individual horizons, HorizonCube

Direct Attributes

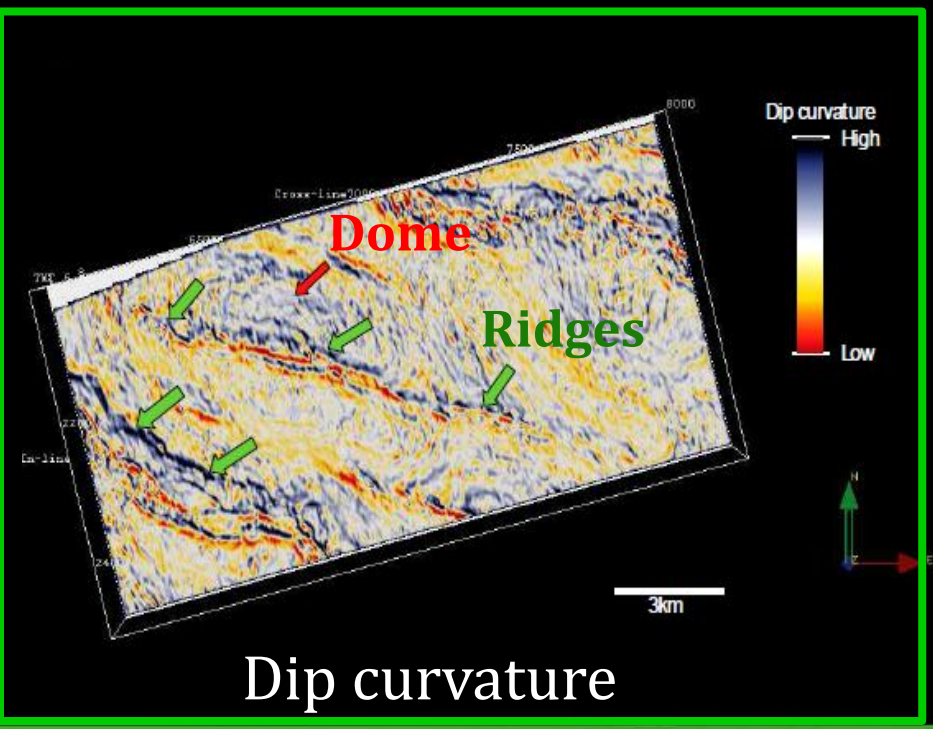
Curvature Example North Sea - small-scale Faults

Most Positive curvature highlights small-scale faults and lineaments

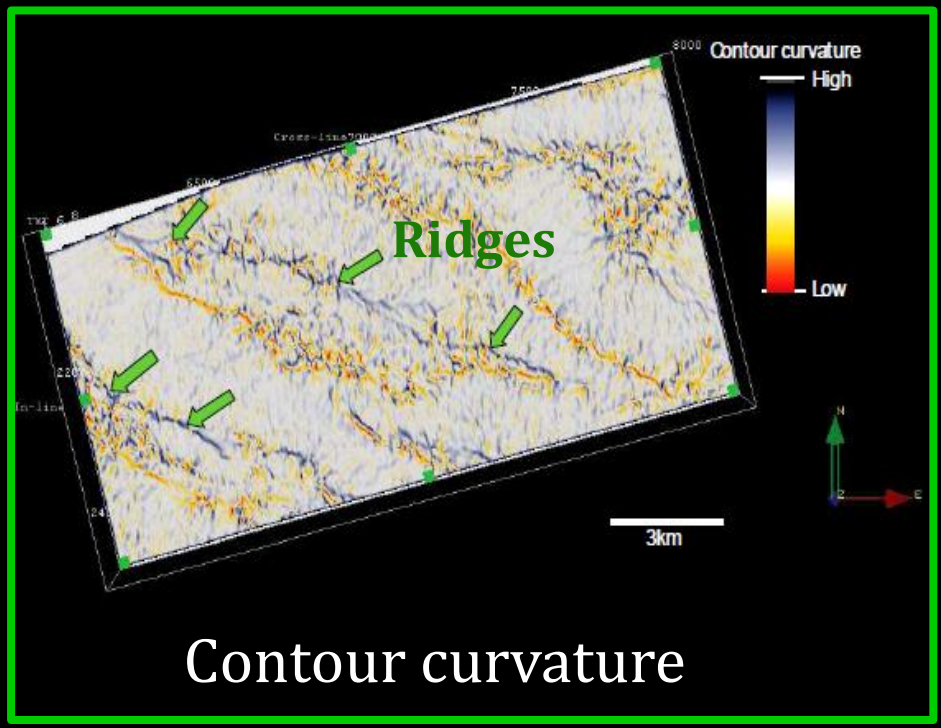


Direct Attributes

Curvature Example Niger Delta- Drainage Patterns



Dip curvature

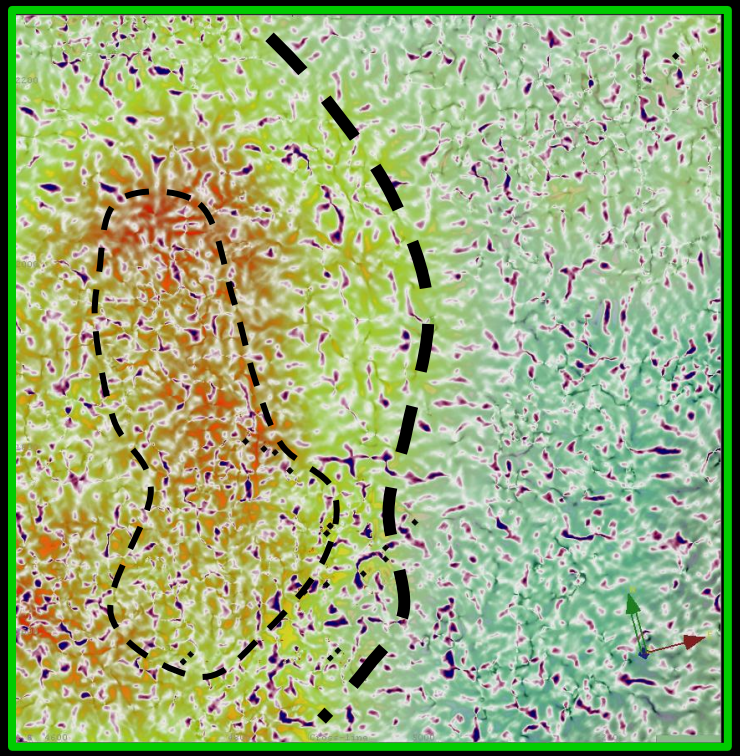


Contour curvature

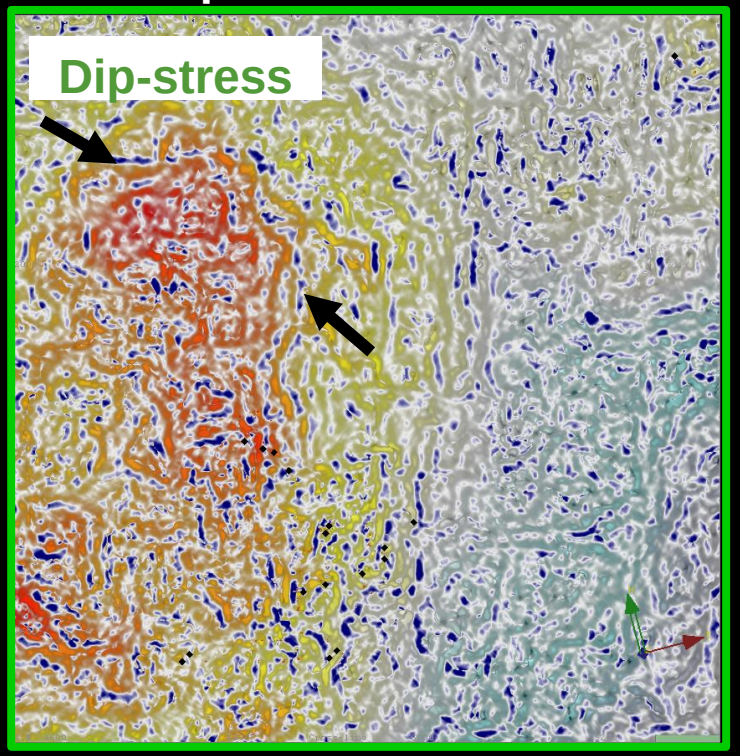
Direct Attributes

Curvature Example Middle East – Stress & Fractures

Strike Curvature 7x7



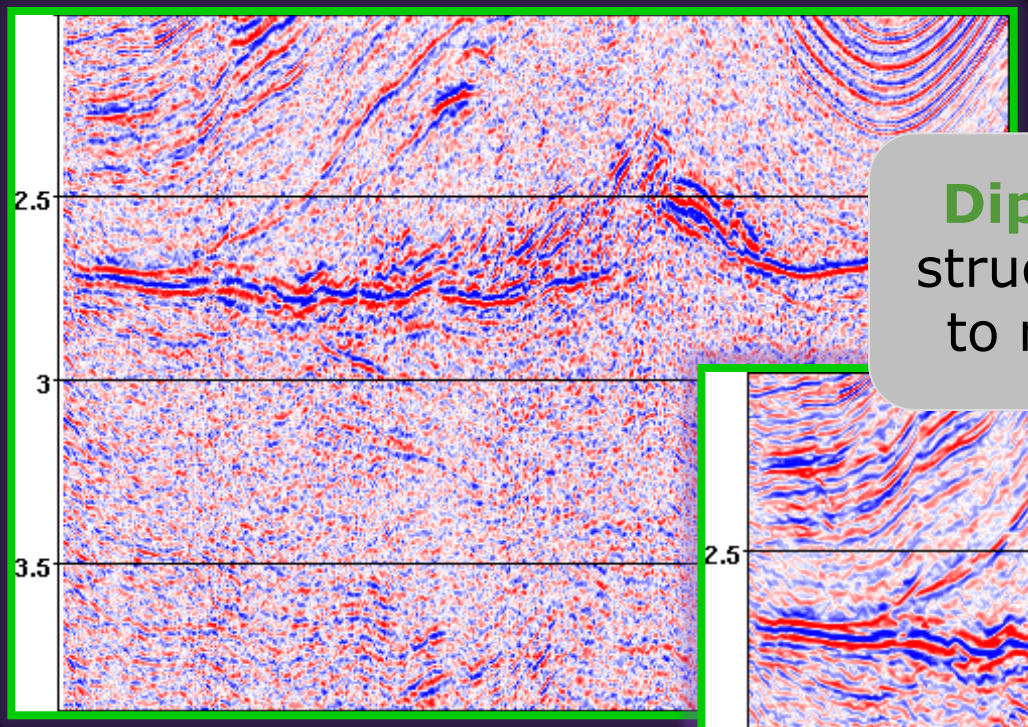
Dip Curvature 7x7



Underlay of red areas mark structural highs

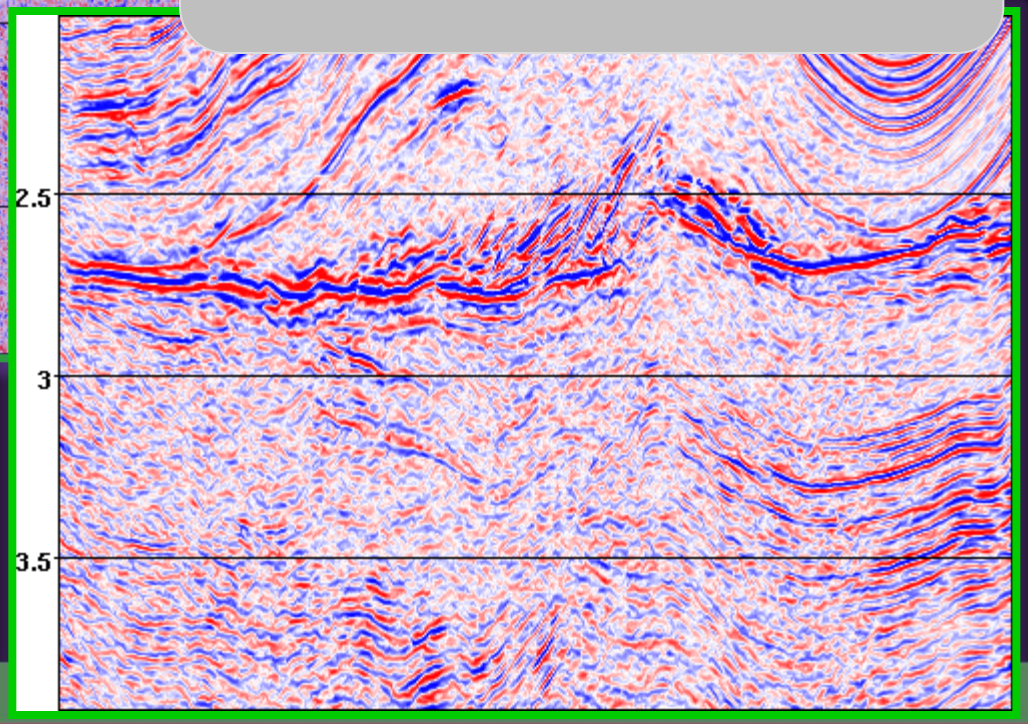
Dip Steered Filtering

Dip Steered Median Filter



Input Seismic

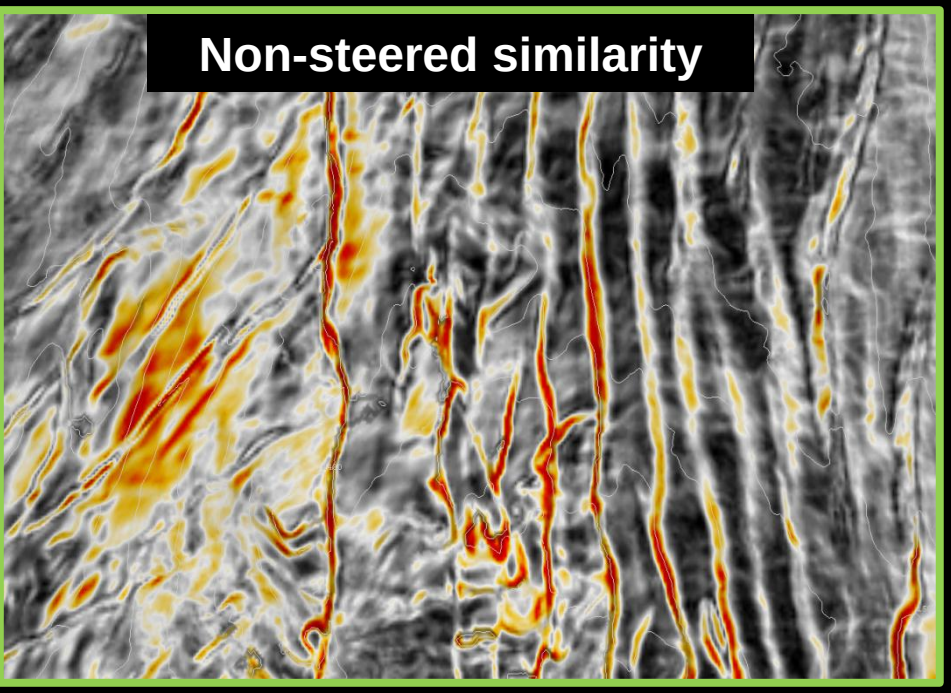
Dip steering is used for structurally-oriented filters to remove random noise

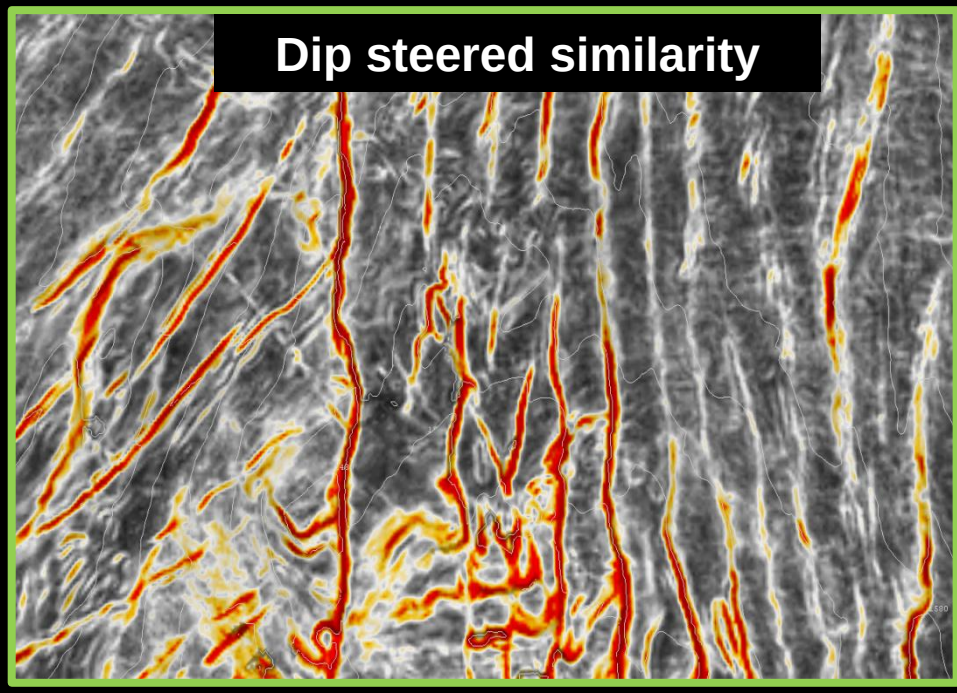


Dip-Steered Median Filter

Dip-steered Attributes

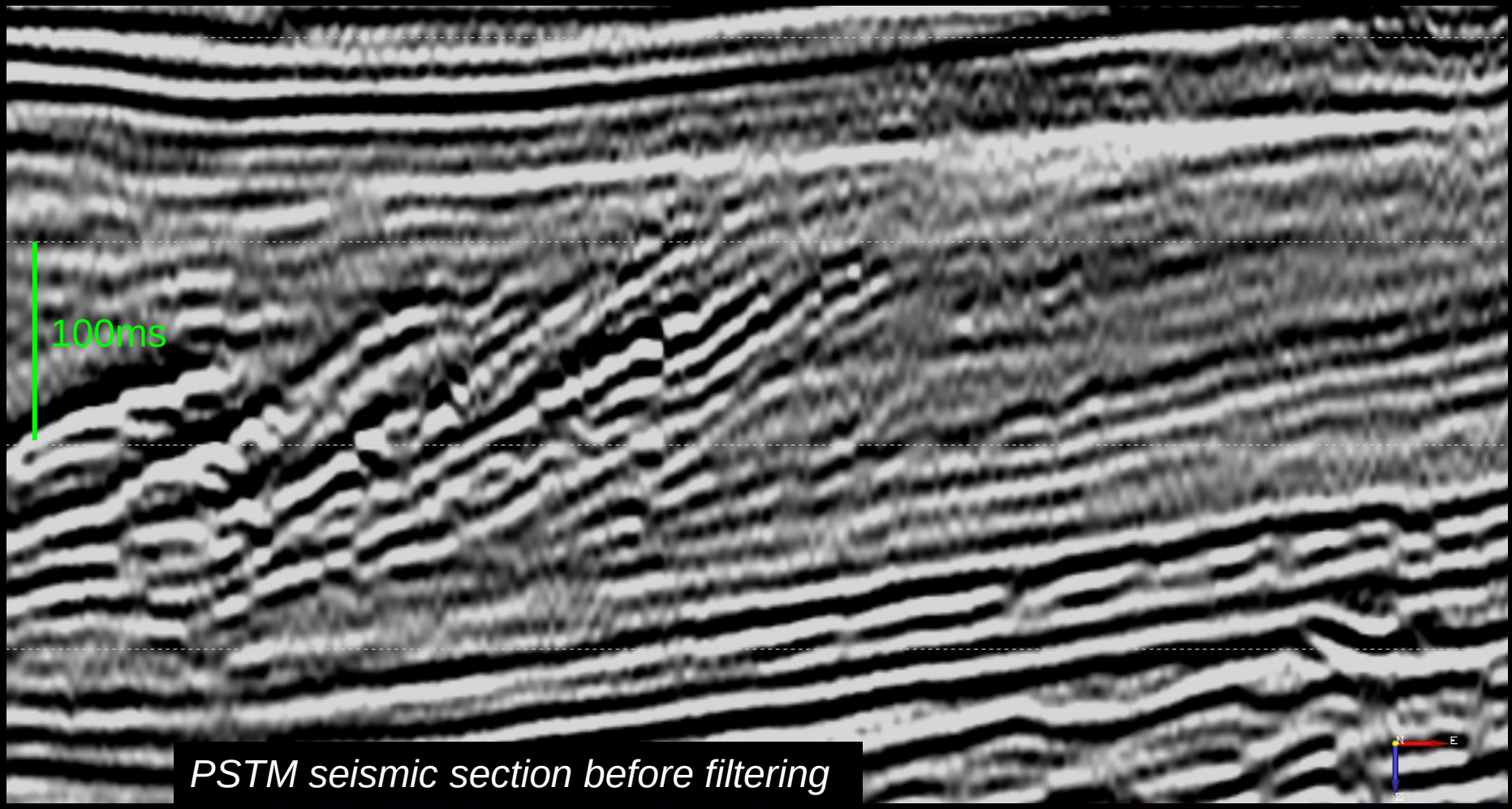
Similarity attribute along mapped horizon (Base Tertiary, North Sea)





Dip Steered Filtering

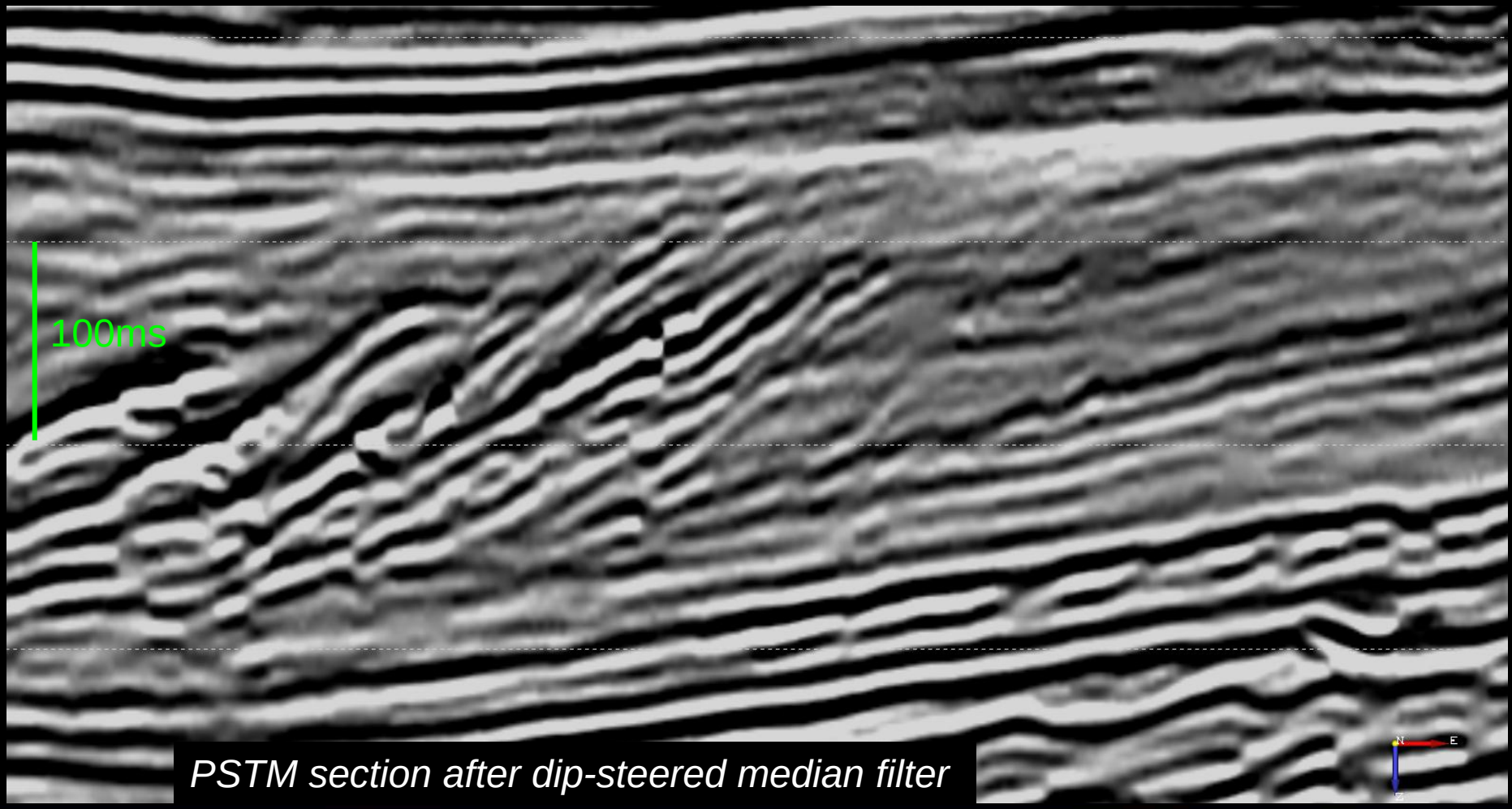
Dip Steered Median Filter



PSTM seismic section before filtering

Dip Steered Filtering

Dip Steered Median Filter



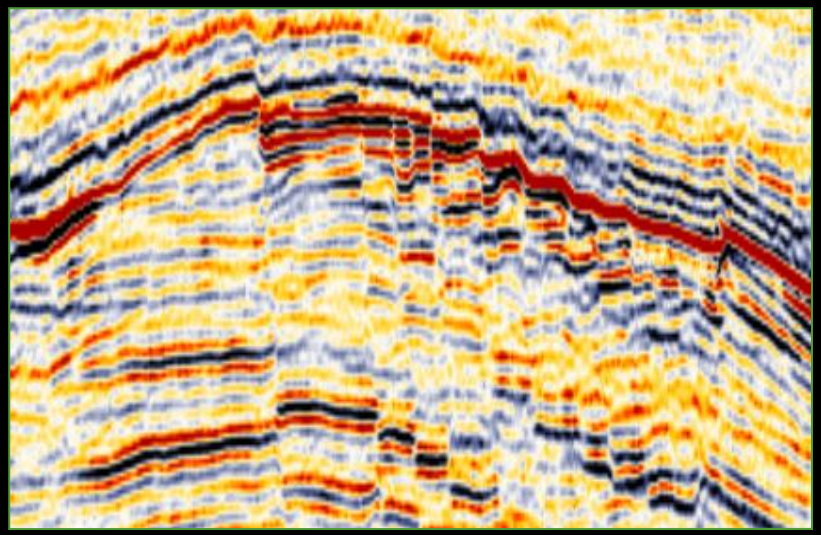
PSTM section after dip-steered median filter

Dip Steered Filtering

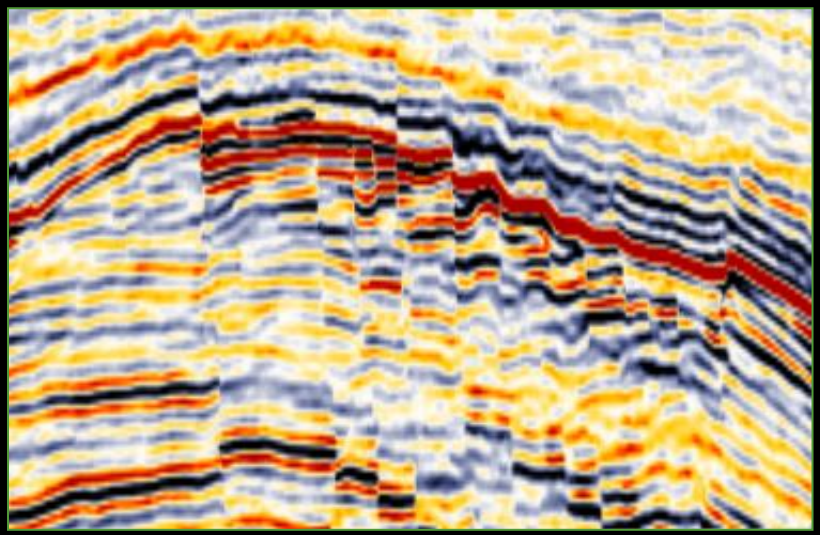
Fault Enhancement Filtering

Fault Enhancement Filter *- Sharpens the fault definition.*

Original



Fault Enhanced

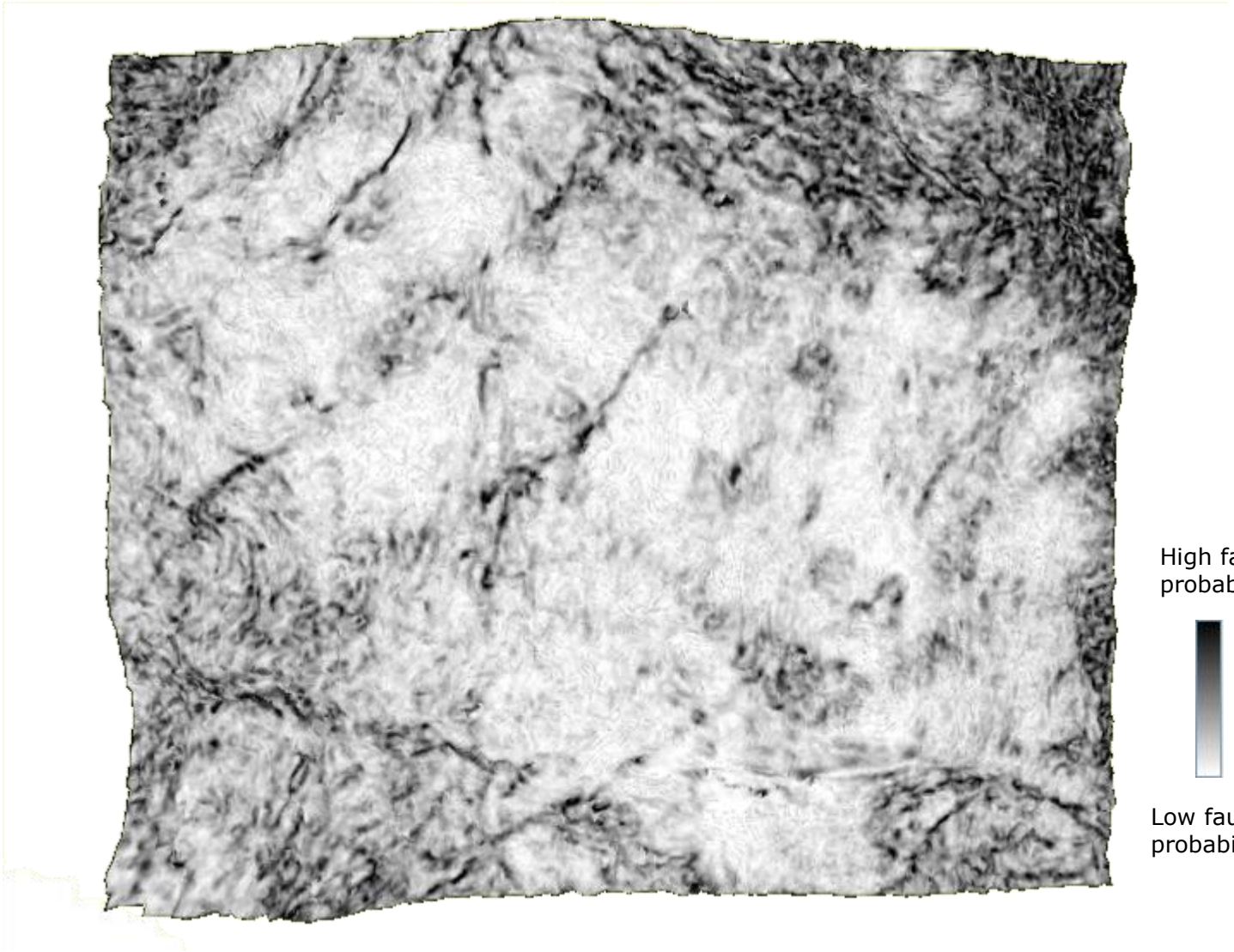


Seismic

Dip Steered Filtering

Fault Enhancement Filtering

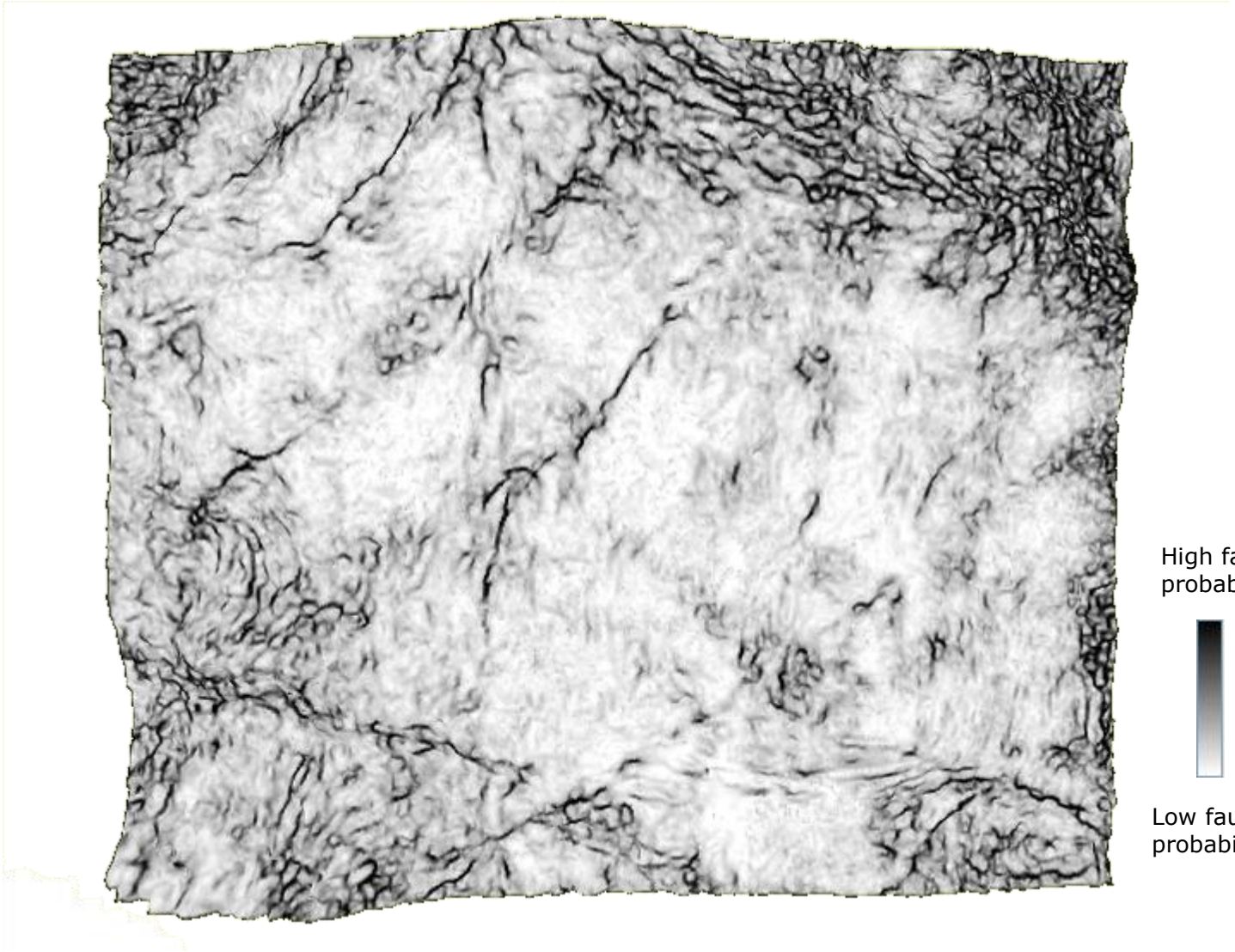
Input: Original Seismic Data



Dip Steered Filtering

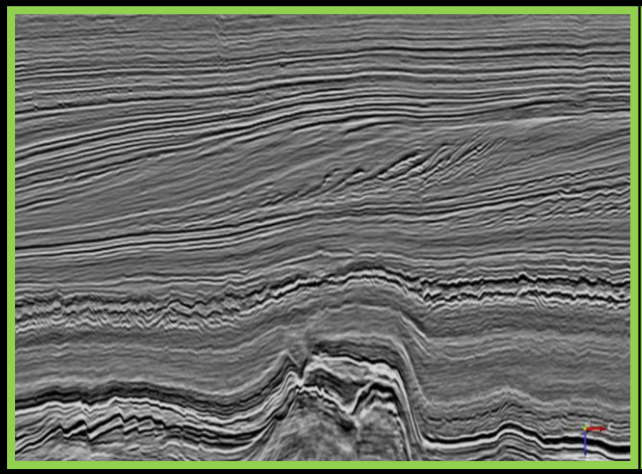
Fault Enhancement Filtering

Input: Seismic Data after Fault Enhancement Filtering

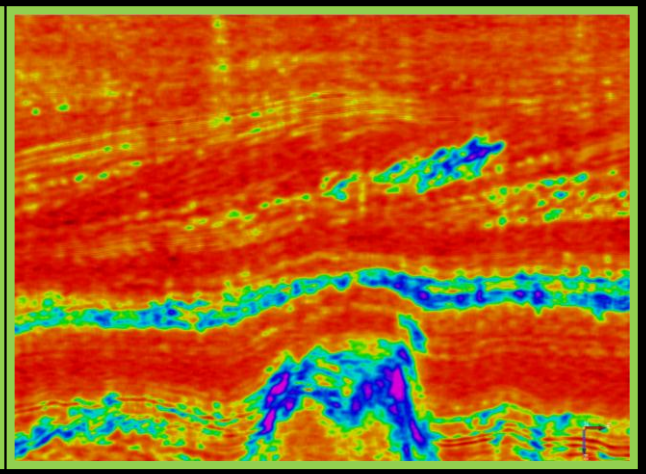


Dip-steered Attributes

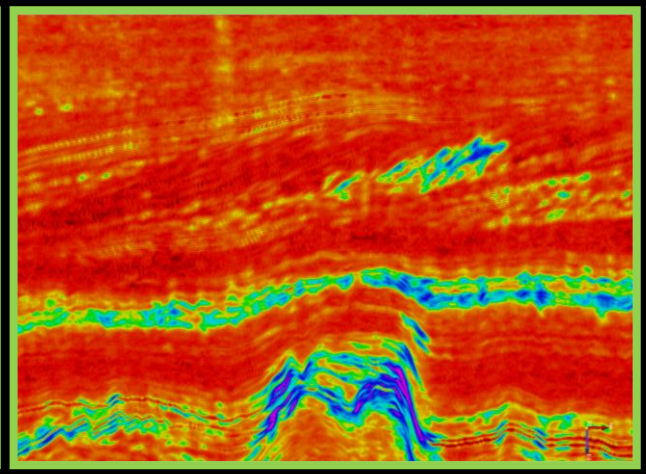
Texture Homogeneity attribute



Seismic Input



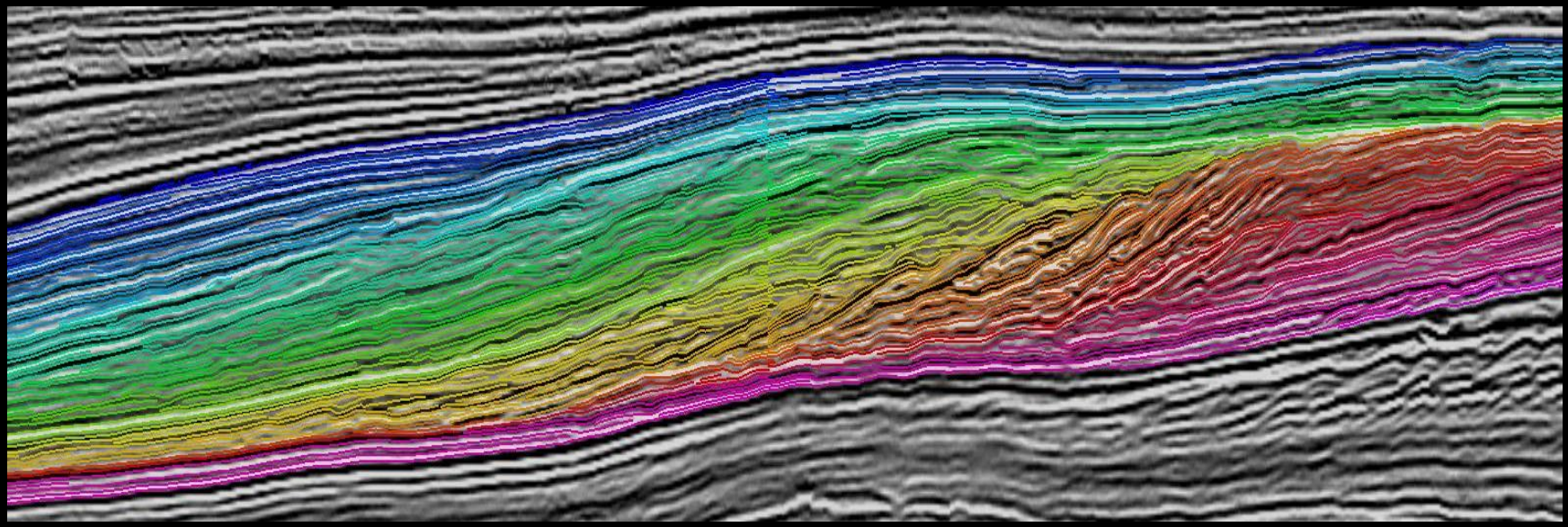
Non-steered Homogeity



Dip-steered Homogeity

Horizon Tracking

HorizonCube generation



Coloured lines are auto-tracked horizons that tracked the dip field.