Tip/Trick: Spectral Decomposition with Petrel

EBN Symposium 'Echoes from Seismic… '

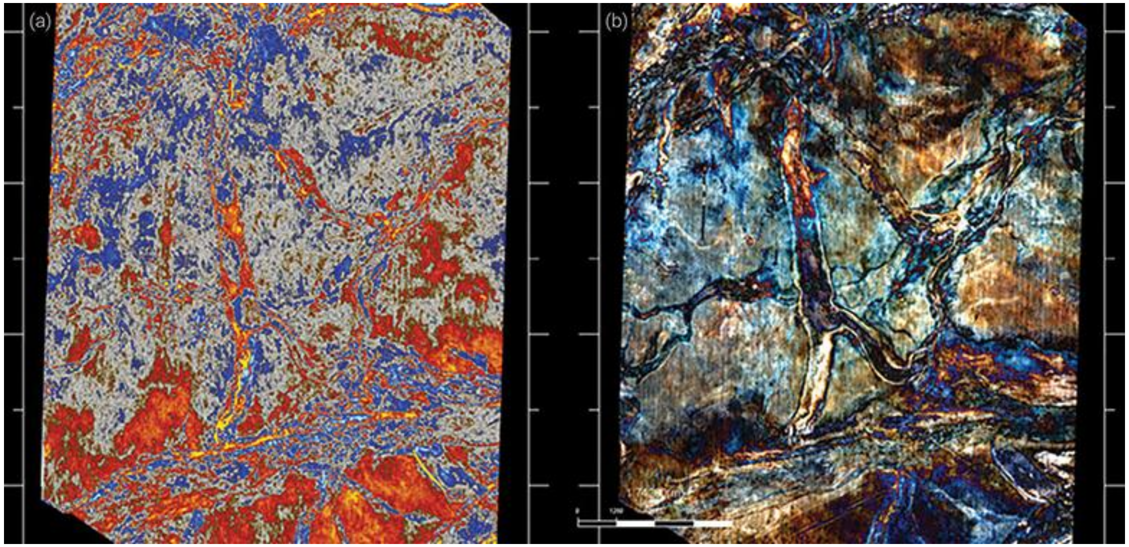
18th February 2016

Reinoud Veenhof

Introduction

- **Spectral decomposition can be a big help in viewing details in your seismic**
  - Adding 'to the eye' frequency information to the standard amplitude data

- **Example of company/software propagating this is GeoTeric**
  - What they call 'Cognitive Interpretation' *(gotta give it a name…)*

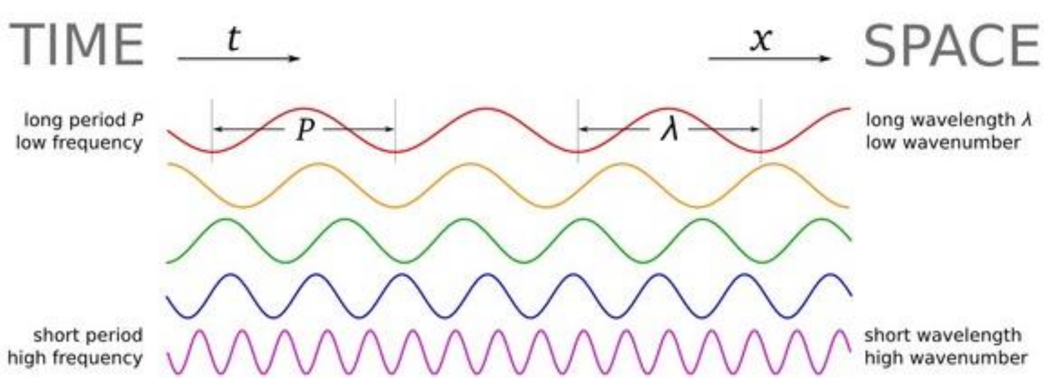


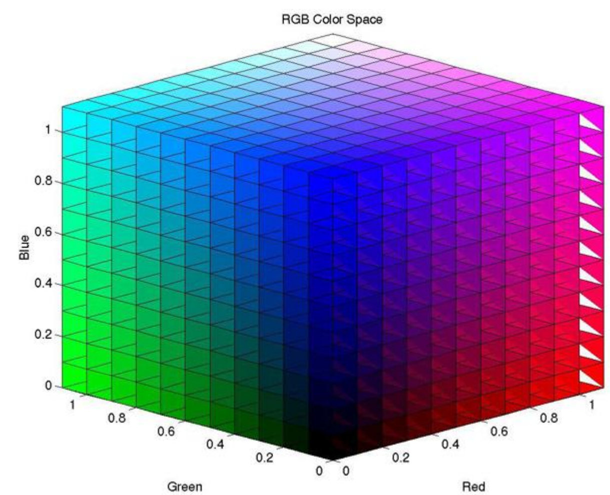
- **This presentation shows how to create the spectral decomposition and display it by yourself with just Petrel**
  - *After Marfurt, Techniques and best practices in multi-attribute display (SEG, 2015)*

ORANJE-NASSAU ENERGIE

Introduction

- **Spectral decomposition in seismic consists of 2 steps**
  1. Selection of the attribute to de-compose
     - Should be meaningful, i.e. attributes that are mathematically independent but correlated through the underlying geology
     - Frequency is the prime attribute (others are dip, azimuth etc.):
       - In time it's called f or temporal frequency (cycle/second = Hz)
       - In depth it's called k or spatial frequency (wave number) = nr of wavelengths/distance = inverse of wavelength = $^1/_\lambda$)

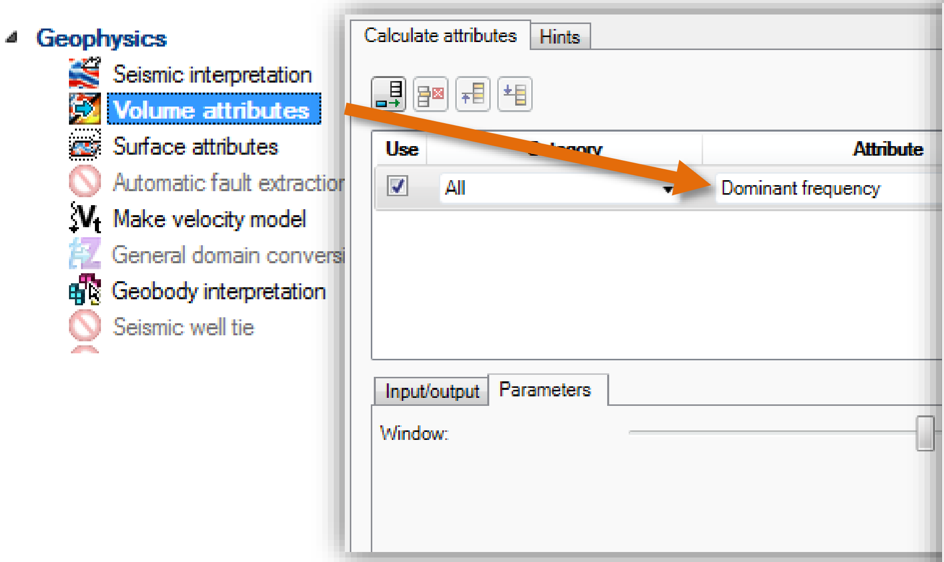


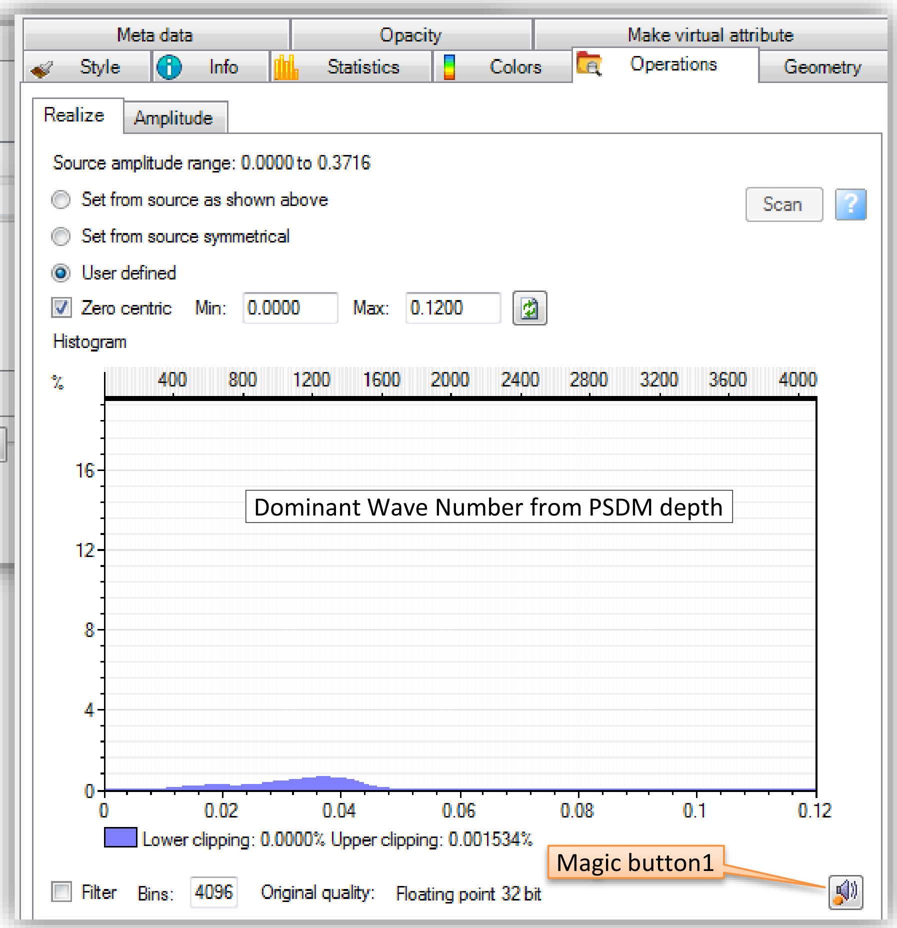


  2. Co-render with the existing seismic display
     - Combination of RGB color model and Alpha (opacity) blending

The Trick – Step 1

- **This can all be done by Petrel…**
  - As an example I take a PSDM processed depth seismic
  - Determine the dominant frequency (by Volume Attribute process):





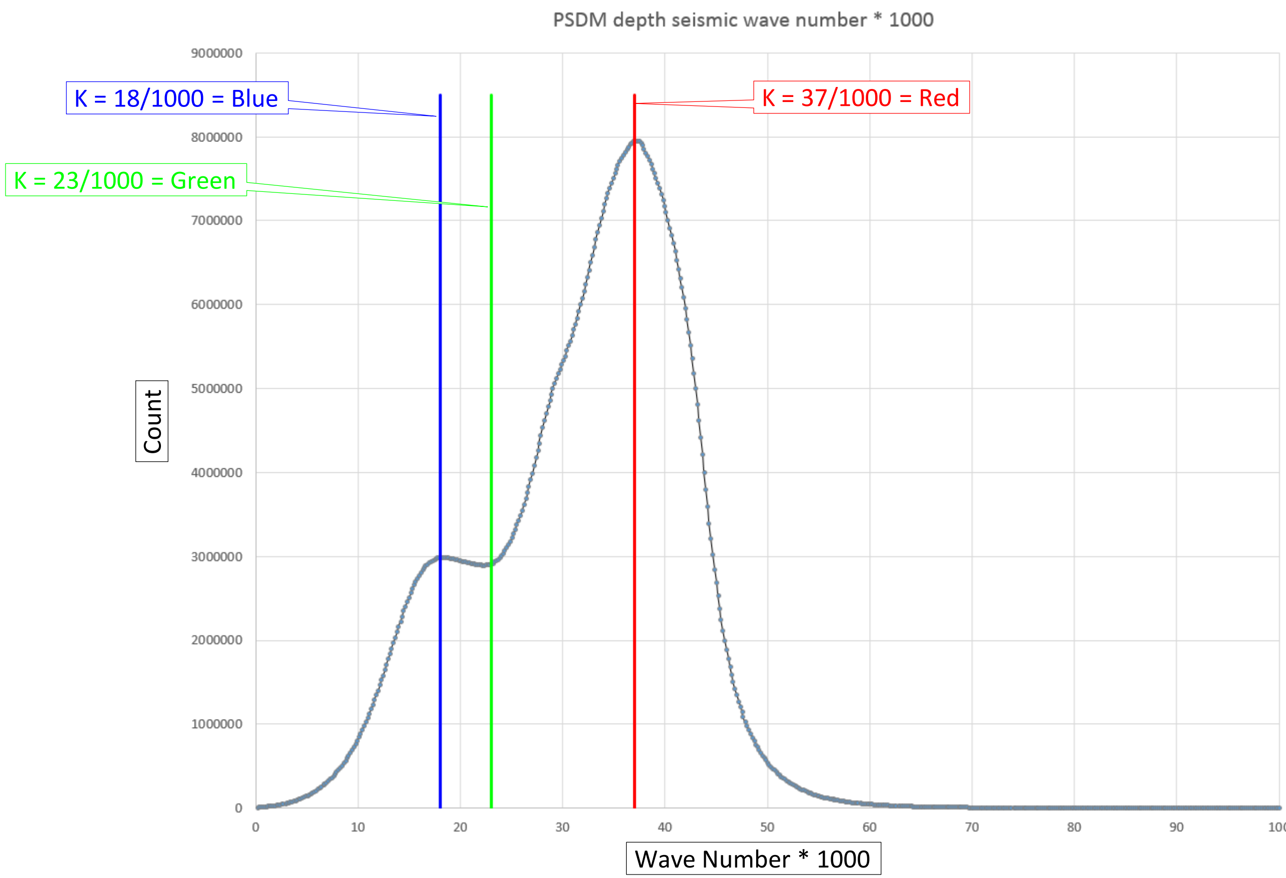
  - A rather meaningless histogram

    But among 100 million buttons…

    Petrel has couple of Magic Buttons

The Trick – Step 1

- **Magic Button 1 pipes all histogram values to the message log (including percentiles) which in Excel gives a meaningful histogram**
  - Multiplying the wave number with 1000 gives units comparable to temporal frequency numbers we are used to.



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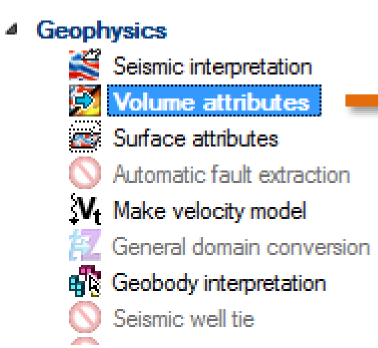
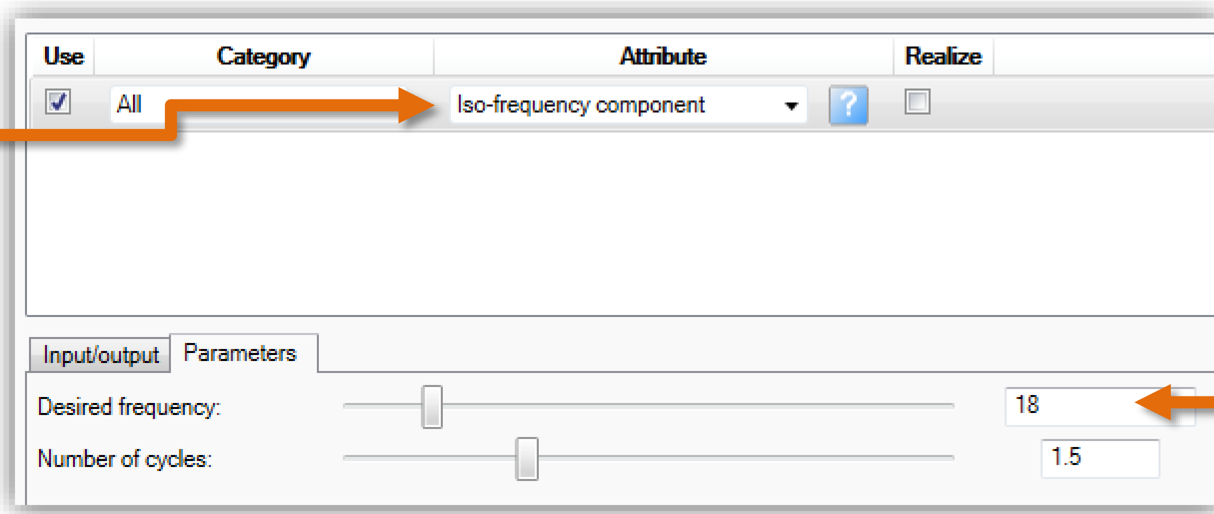
The Trick – Step 1

- **I assign the following 'components':**
  - Wave number = 18/1000 = Blue
  - Wave number = 23/1000 = Green
  - Wave number = 37/1000 = Red

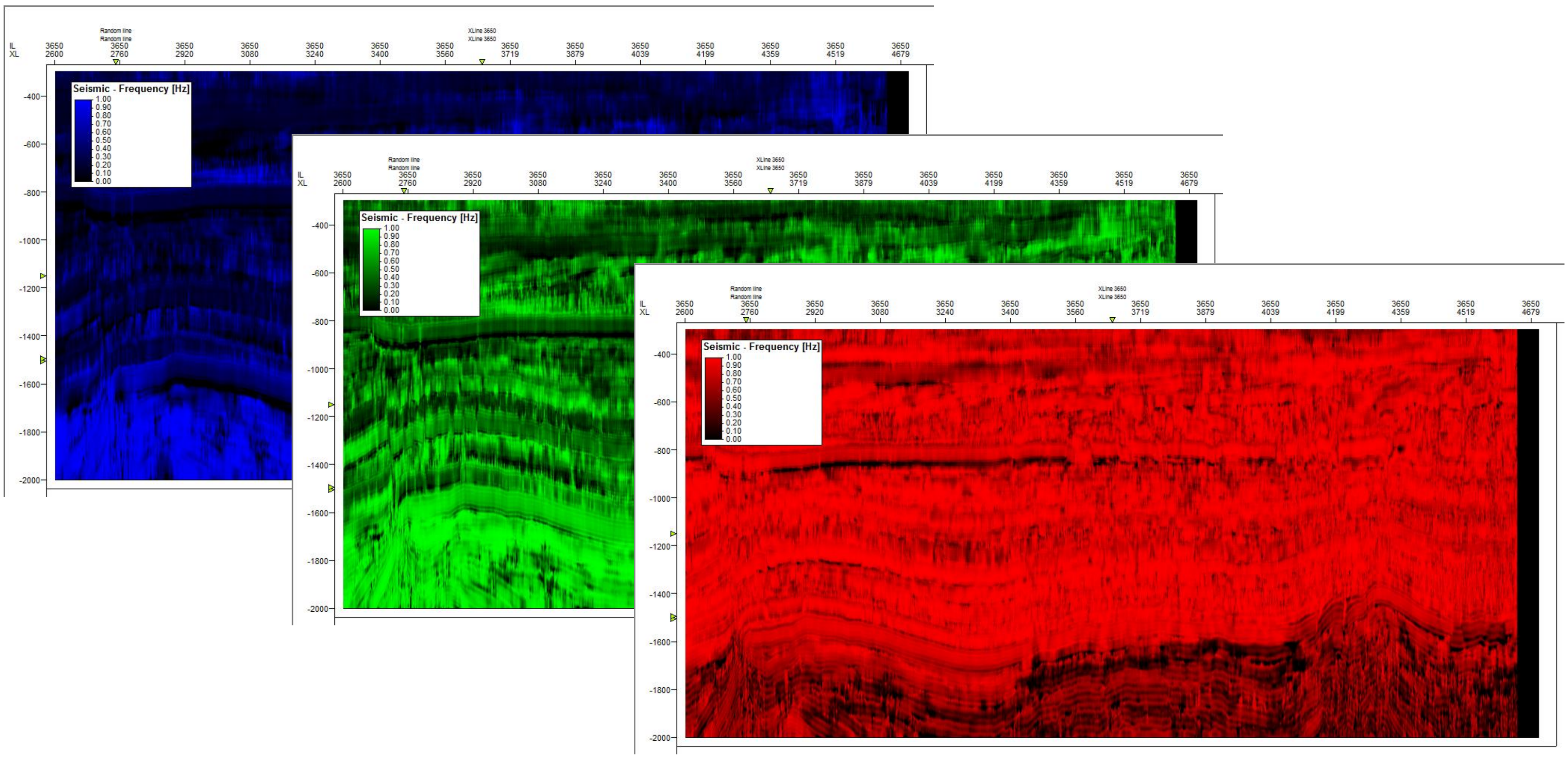
- **Next is extracting these dominant frequencies from the PSDM**
  - Petrel has a volume attribute process for this called 'Iso-frequency component' which is the isolation of the local contribution of individual frequencies to the make-up of the input signal





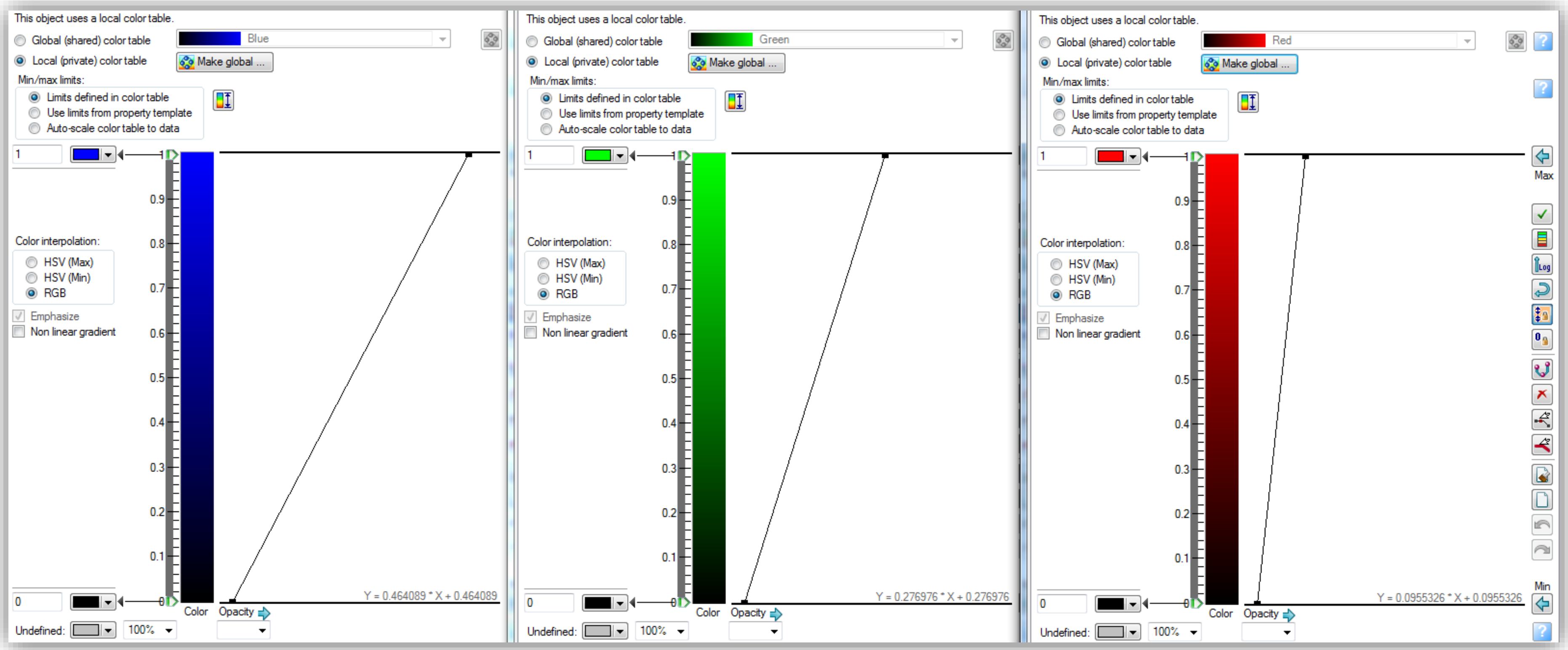
The Trick – Step 1 and 2

- **The Iso-frequency component is a normalized measure of contribution of that specific frequency to the total seismic input at a specific location**
  - These can be colored by a color scale where 0 = no color and 1 is full monochrome color of either blue, green or red



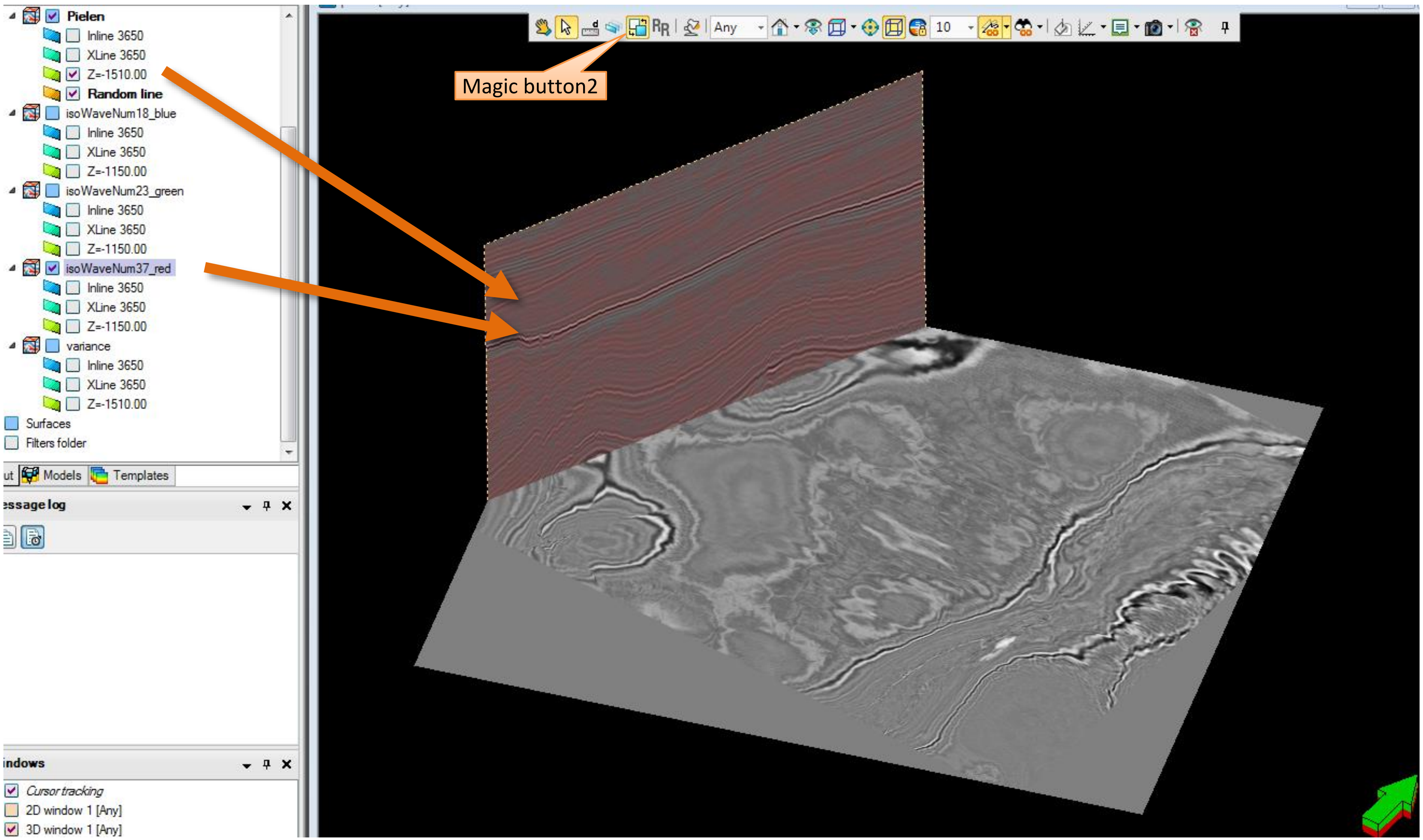
The Trick – Step 2

- **Opacity blending the separate seismic volumes**
  - Define opacity level for the three monochrome volumes where 0 should be completely transparent and 1 is a '*certain percentage*' of that color
  - A '*certain percentage*' means whatever brings out the geology best



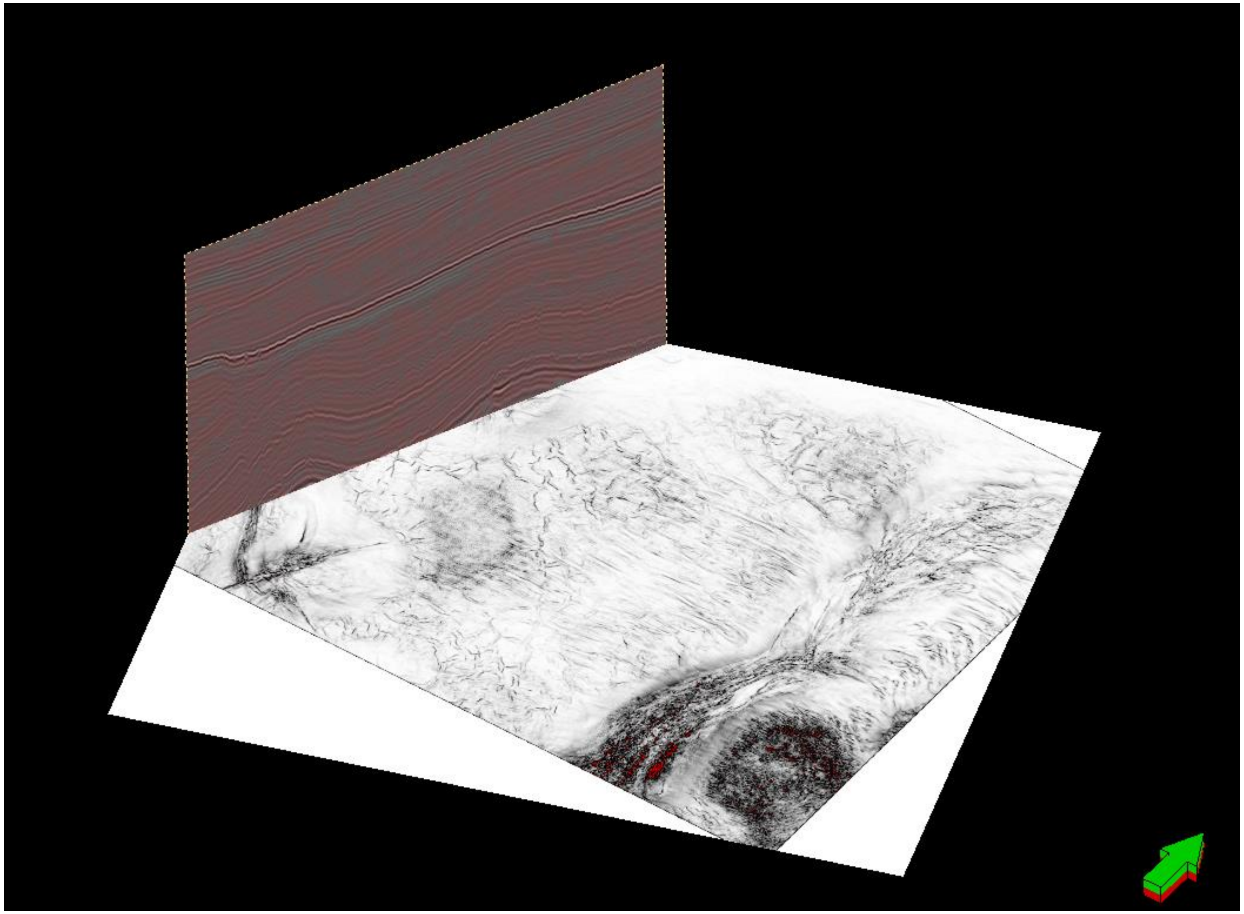
The Trick – Step 2

- **Co-rendering the normal seismic with volume red with Magic Button 2**



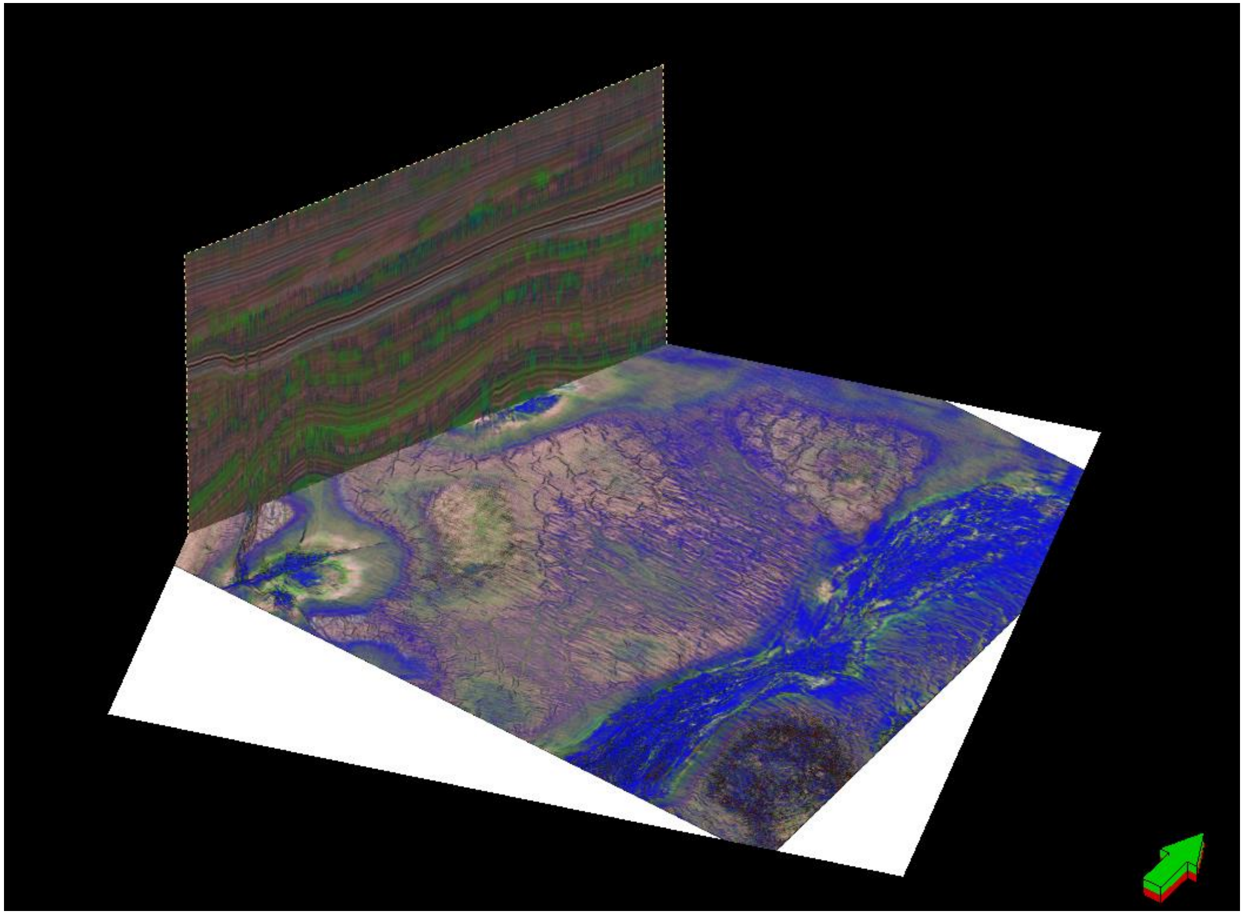
The Trick – Step 2

- **Frequency spectral decomposition on depth slices works best with coherency (or variance) cubes instead of normal seismic**

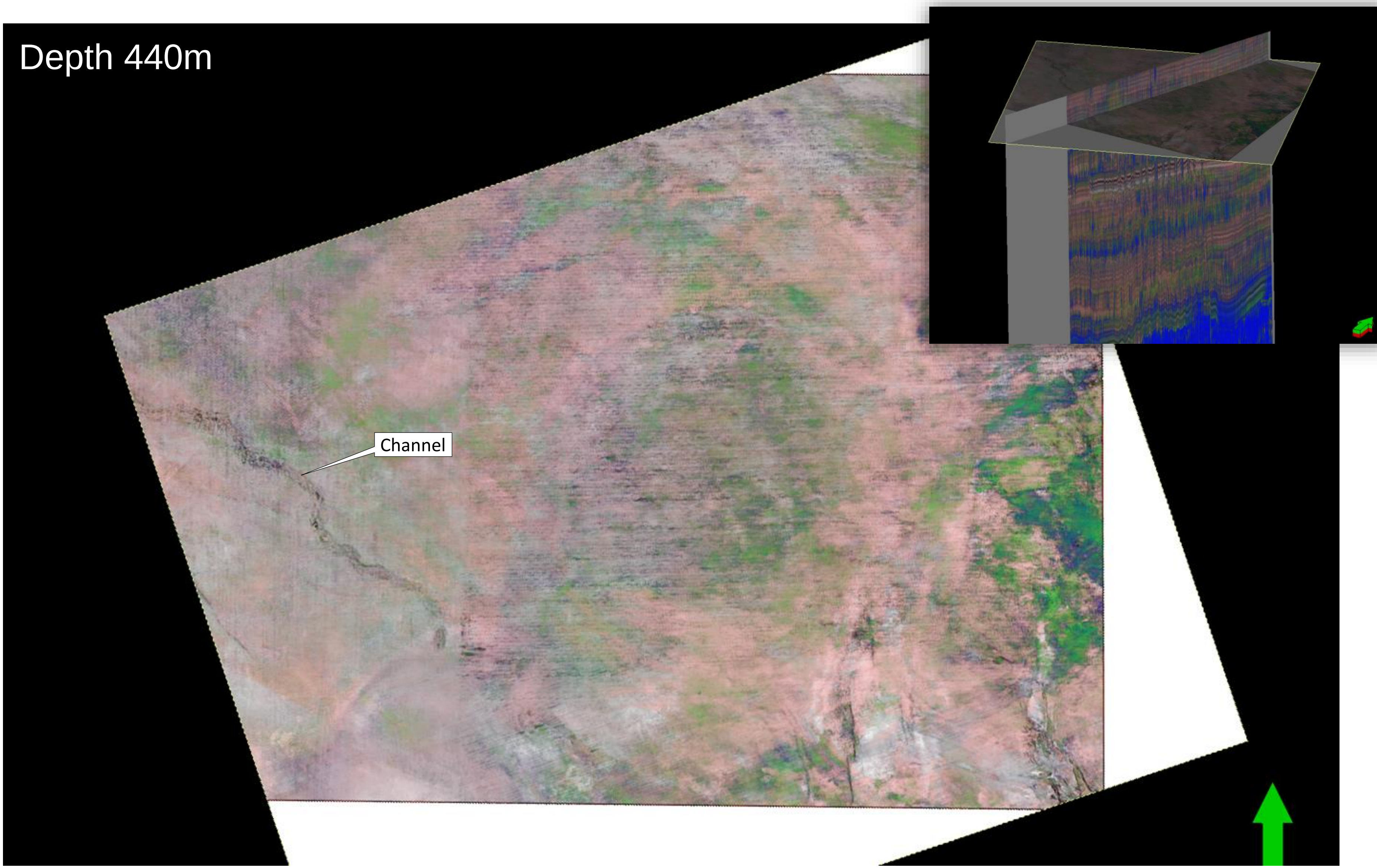


The Trick – Step 2

- **All volumes rendered with normal seismic as backdrop for the vertical section and coherency as backdrop for the horizontal slice**



The Show



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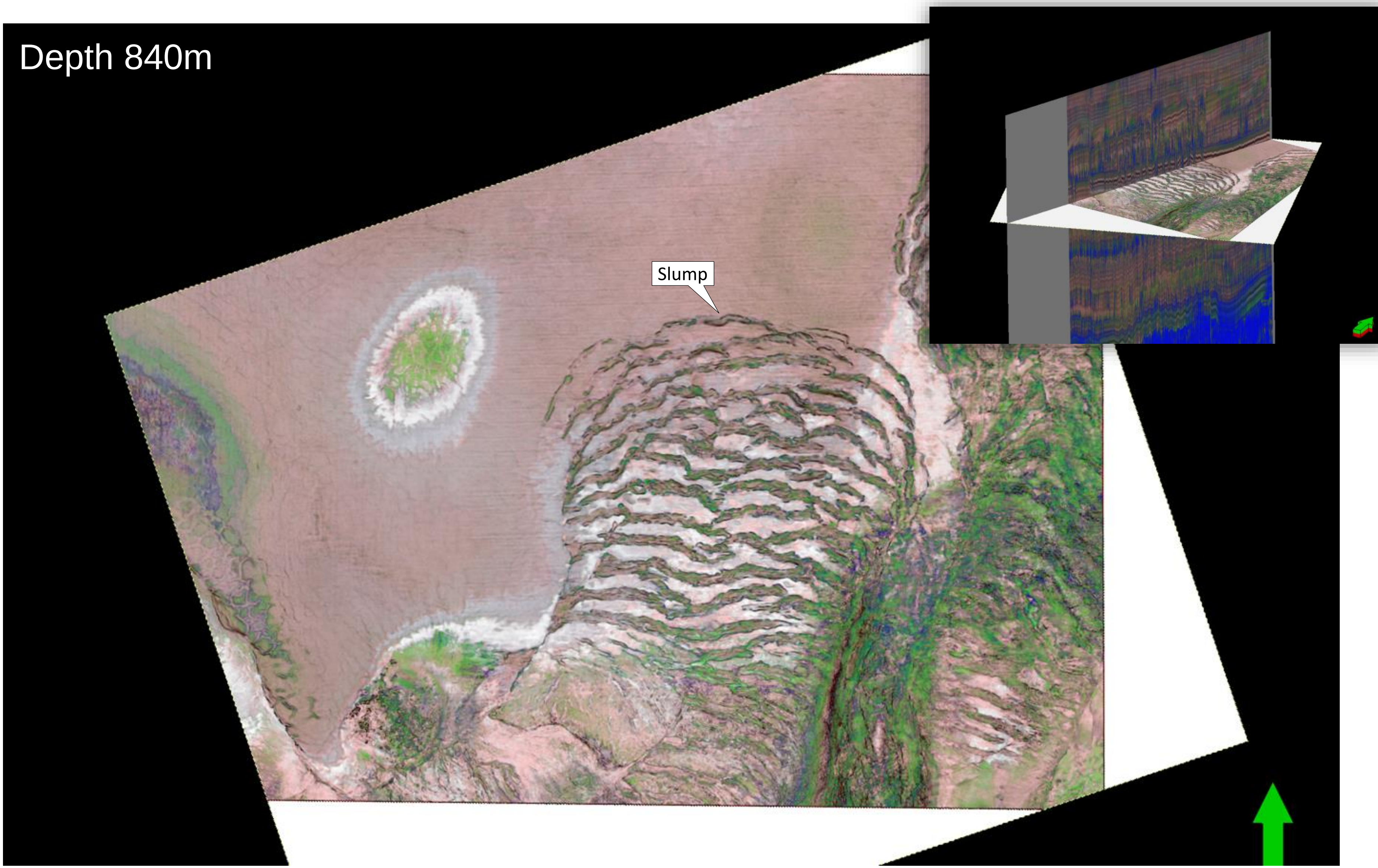

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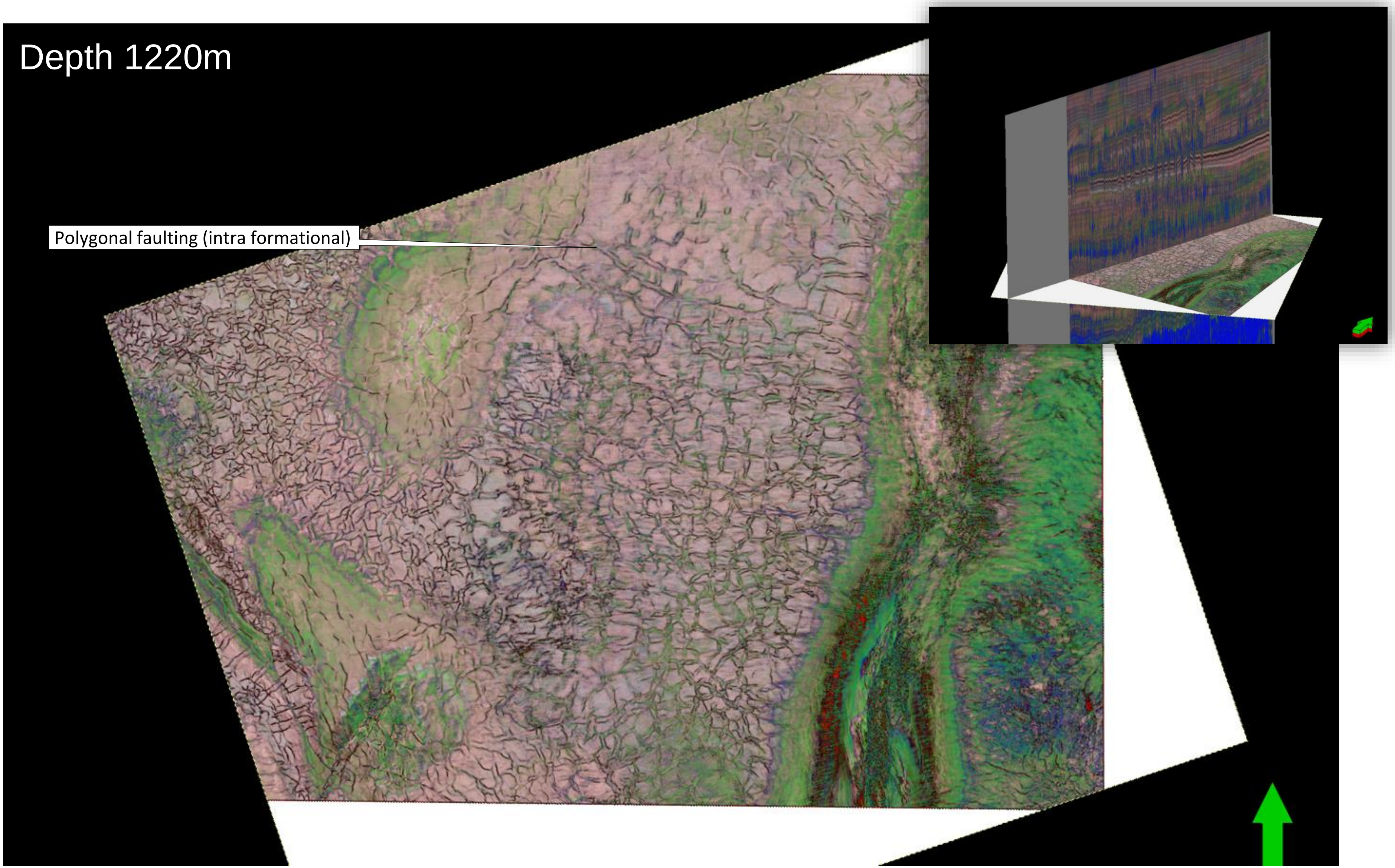

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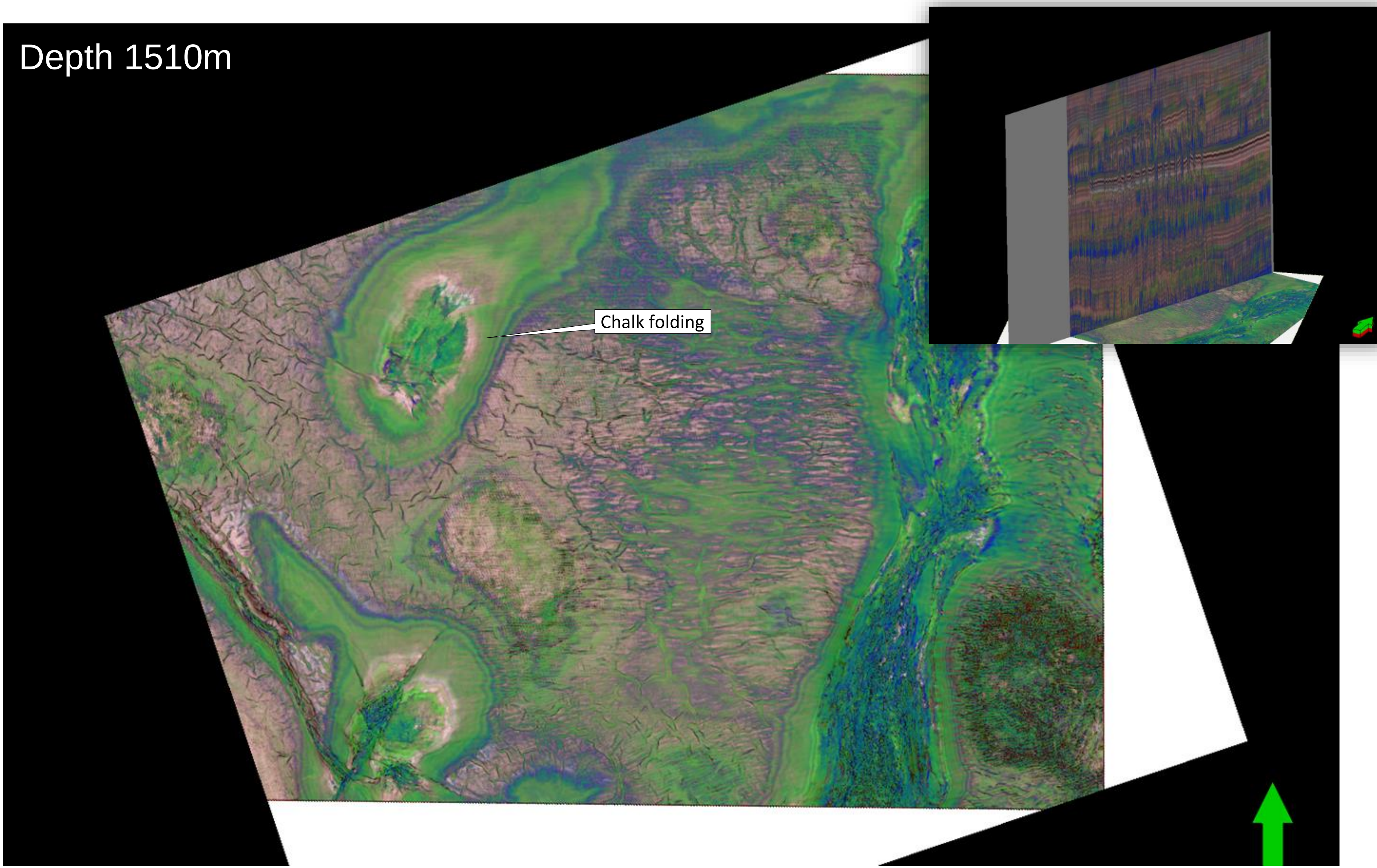

The Tip

- **A partial list of attributes that can be effectively displayed with blending a color model**
  - From: Marfurt, Techniques and best practices in multi-attribute display (SEG, 2015)

i.e. backdrop

Background attribute (against hue)	Modulating attribute (against saturation)	Calibration attribute (against lightness)	Reference
Dip azimuth	Dip magnitude	Coherence on time slices. Amplitude on vertical slices.	Figure 12, Rijks and Jauffred (1991), Marfurt et al. (1998)
Strike of most-positive principal curvature	Positive value of most-positive principal curvature	Coherence on time slices. Amplitude on vertical slices.	Figure 16, Guo et al. (2013)
Strike of most-negative principal curvature	Positive value of most-negative principal curvature	Coherence on time slices. Amplitude on vertical slices.	Marfurt (2010), Guo et al. (2010)
Reflector shape index	Reflector curvedness	Coherence on time slices. Amplitude on vertical slices.	Figure 14, Mai et al. (2009), Marfurt (2010)
Peak spectral frequency	Peak spectral magnitude	Coherence on time slices. Amplitude on vertical slices.	Figure 17, Guo et al. (2008)
Azimuth of reflector convergence	Magnitude of reflector convergence	Coherence on time slices. Amplitude on vertical slices.	Figure 15, Marfurt (2010), Marfurt and Rich (2010), Chopra and Marfurt (2011)
Azimuth of HTI anisotropy	Magnitude of HTI anisotropy	Confidence of fit, coherence, most-positive curvature, most-negative curvature on time slices. Amplitude on vertical slices.	Guo et al. (2010), Zhang et al. (2013)
Azimuth of vector correlation	Magnitude of vector correlation	Coherence on time slice. Amplitude on vertical slices.	Guo et al. (2013)
Most likely facies number	None	Probability of facies	Espersen et al. (2000)

Thanks

- **That's all there is to it…**