Classical Seismic Attributes

Seismic Attribute Categories		
CATEGORY	**TYPE**	**INTERPRETIVE USE**
Instantaneous Attributes	Reflection Strength, Instantaneous Phase, Instantaneous Frequency, Quadrature, Instantaneous Q	Lithology Contrasts, Bedding Continuity, Porosity, Direct Hydrocarbon Indicators, Stratigraphy, Thickness
Geometric Attributes	Semblance and Eigen-Based Coherency/Similarity, Curvature (Maximum, Minimum, Most Positive, Most Negative, Strike, Dip)	Faults, Fractures, Folds, Anisotropy, Regional Stress Fields
Amplitude Accentuating Attributes	RMS Amplitude, Relative Acoustic Impedance, Sweetness, Average Energy	Porosity, Stratigraphic and Lithologic Variations, Direct Hydrocarbon Indicators
AVO Attributes	Intercept, Gradient, Intercept/Gradient Derivatives, Fluid Factor, Lambda-Mu-Rho, Far-Near, (Far-Near) Far	Pore Fluid, Lithology, Direct Hydrocarbon Indicators
Seismic Inversion Attributes	Colored Inversion, Sparse Spike, Elastic Impedance, Extended Elastic Impedance, Prestack Simultaneous Inversion, Stochastic Inversion	Lithology, Porosity, Fluid Effects
Spectral Decomposition	Continuous Wavelet Transform, Matching Pursuit, Exponential Pursuit	Layer Thicknesses, Stratigraphic Variations

Roden et al, 2015

Coherency:

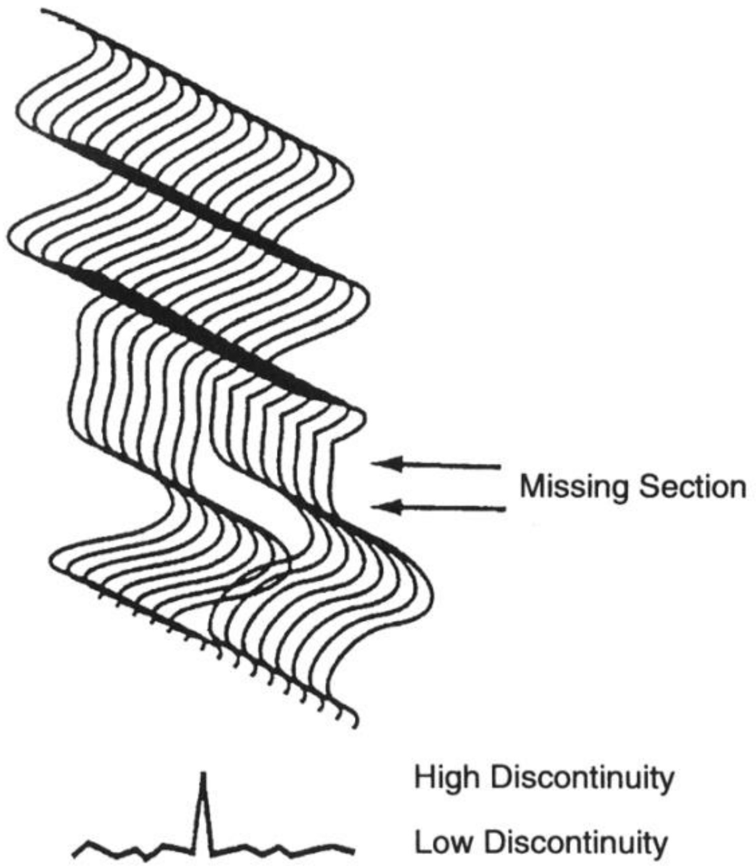

Figure 3. Faults are highlighted by the 3-D coherence technique because traces are not identical on opposite sides of a fault. In this example, missing stratigraphic section from one side of a fault to another generates slightly different reflectivity on one side of the fault. The coherence is lower when the traces are less similar.

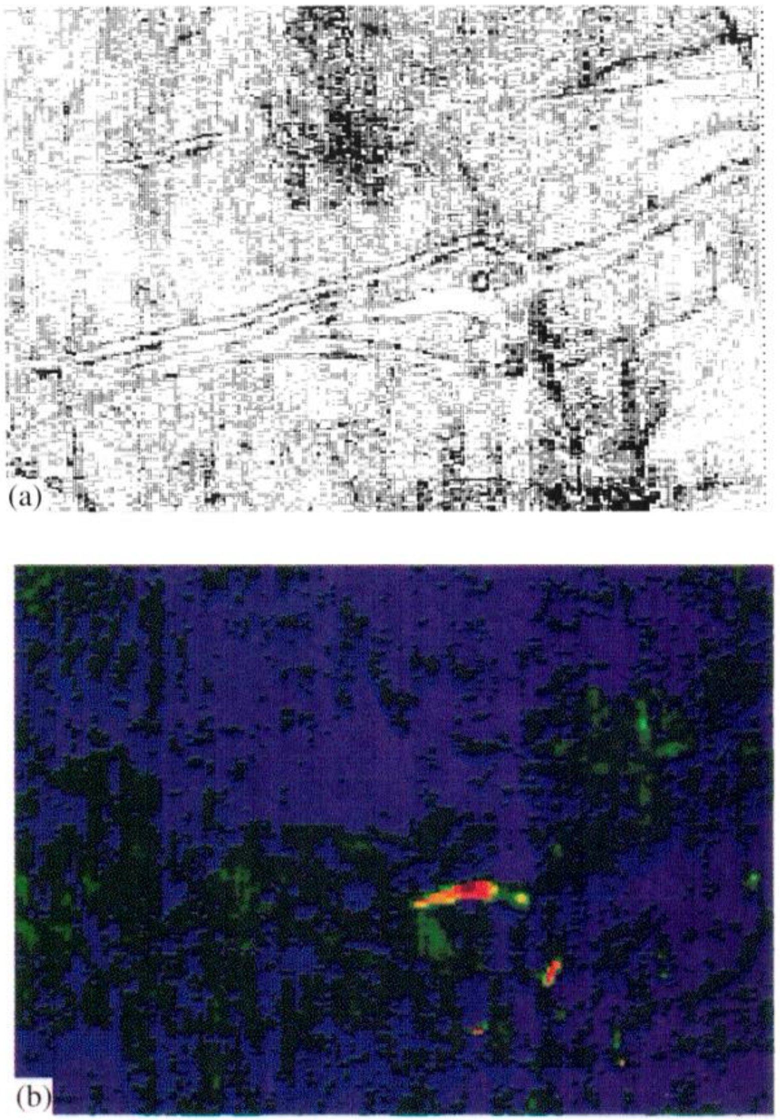

Figure 4. (a) Coherence slice across a channel system. Coherence images the stratigraphic context better while amplitude data in the next panel image hydrocarbons more clearly. (b) Average amplitude over a series of time slices. Note that the bright spot is located within the channel seen on the coherence display.

Bahorich and Farmer, 1995

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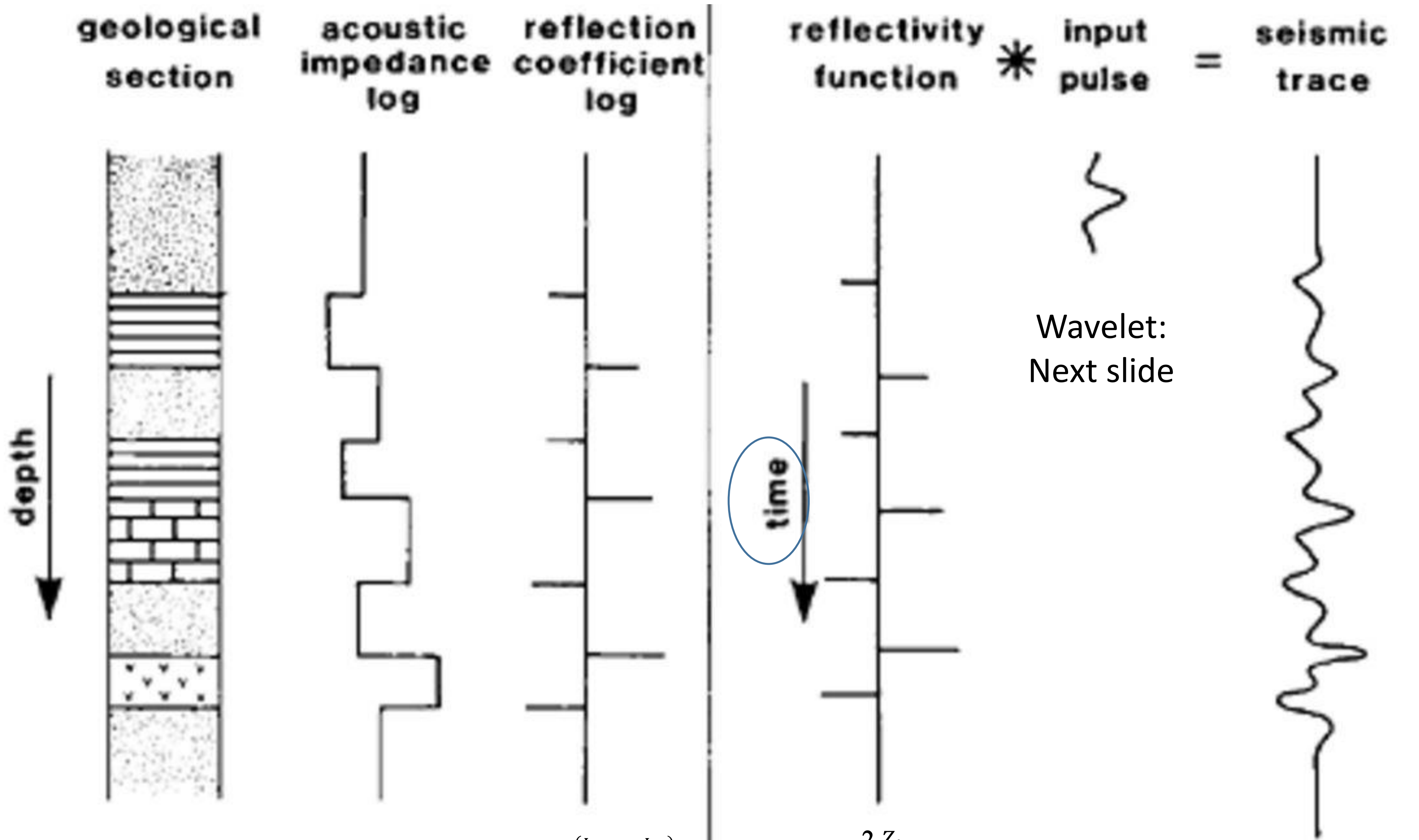
Roden et al, 2015

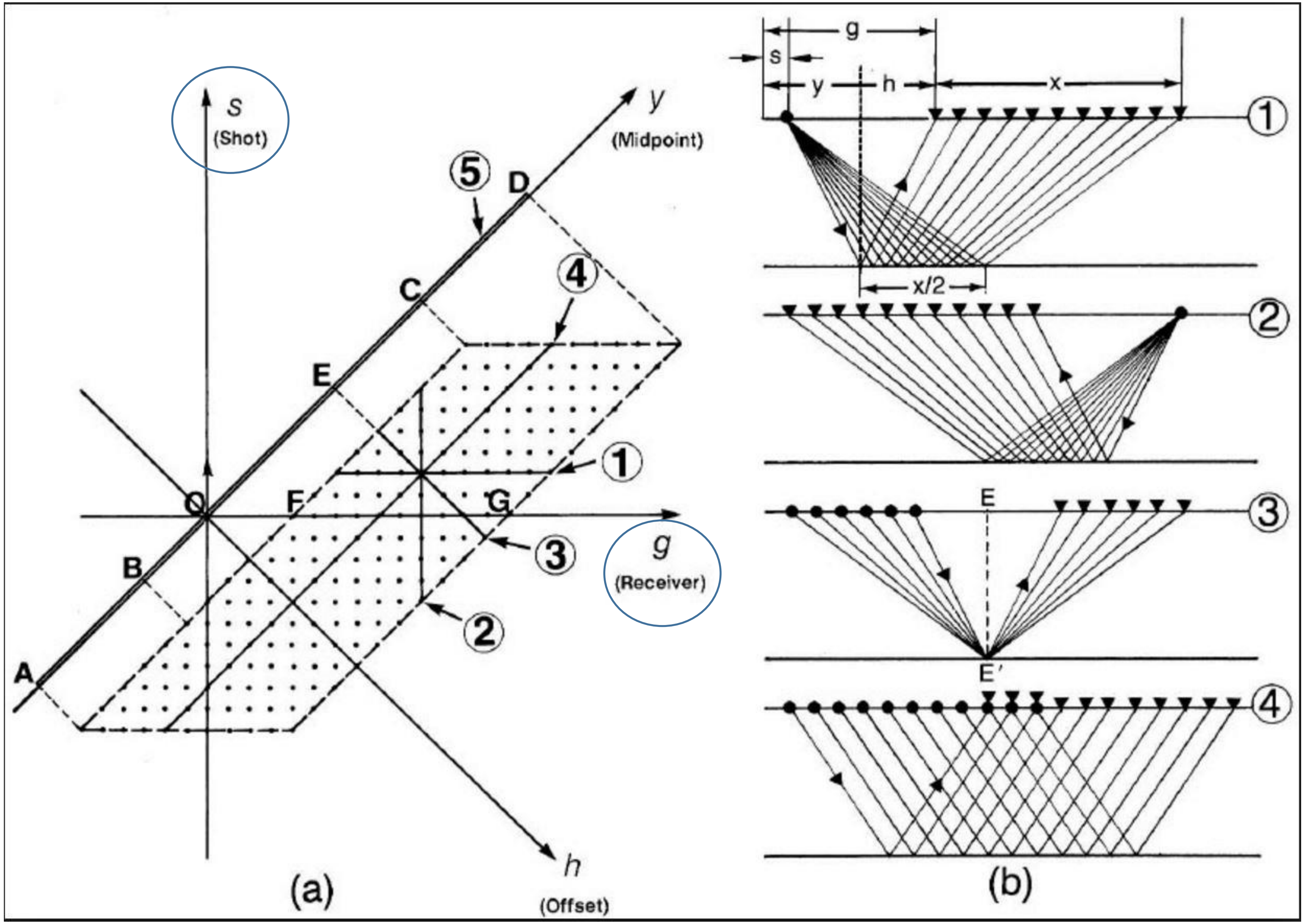
1D Normal Incidence Reflection Coefficient



$[\boldsymbol{Vp}, \boldsymbol{Vs}, \boldsymbol{Rho}]$ $\boldsymbol{Ip} = \boldsymbol{Vp} * \boldsymbol{Rho}$ $\Delta \boldsymbol{Ip} = \frac{(Ip_{i+1} - Ip_i)}{(Ip_{i+1} + Ip_i)}$ $\Delta t_i = \frac{2\, Z_i}{Vp_i}$

Kearey et al, 1991

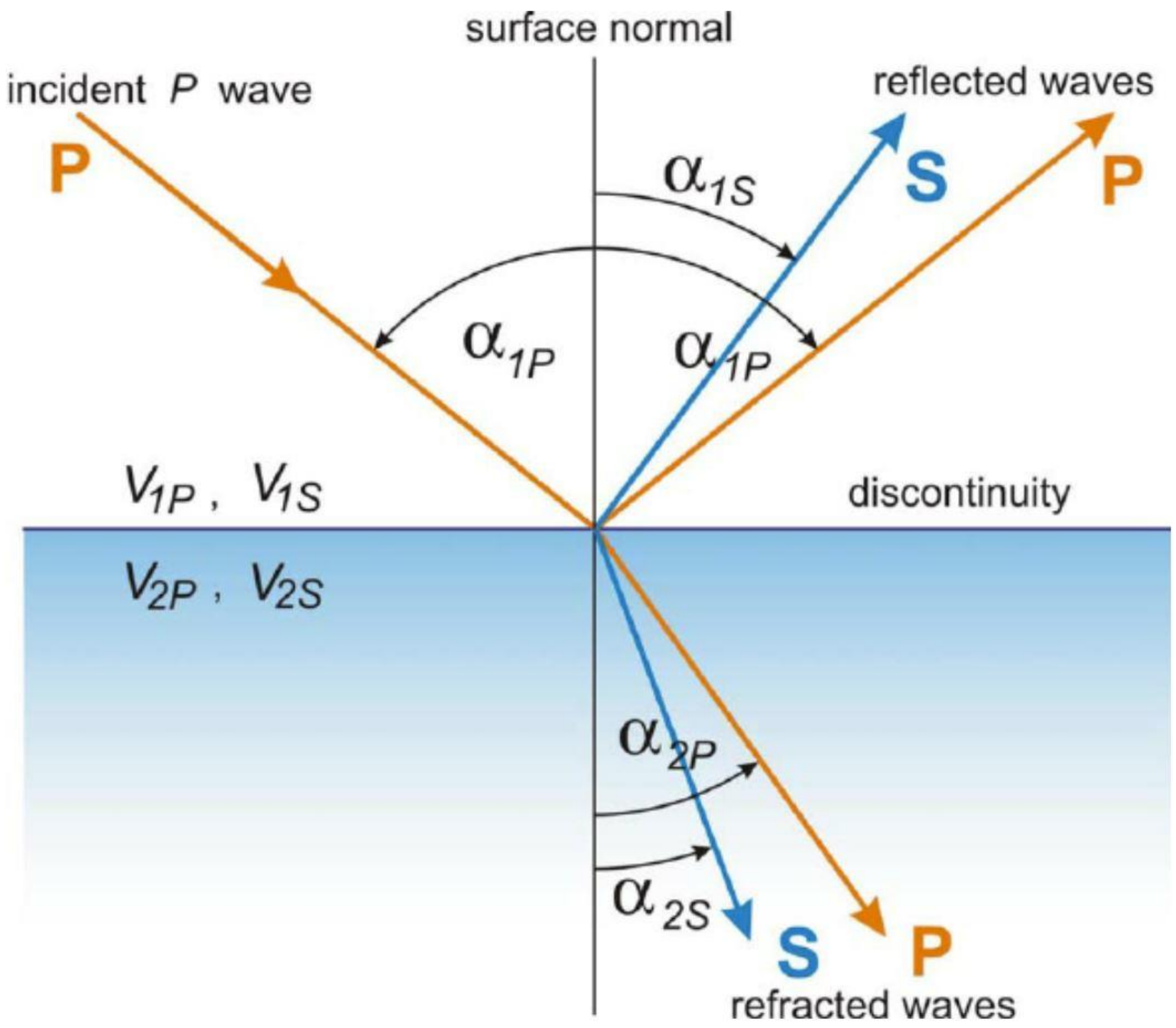
Seismic Data Acquisition - Land



Why do we bother with non-NI data acquisition?

SEG Wiki

Reflected P-wave with Offset in isotropic Media…



PP-wave Reflection Isotropic:

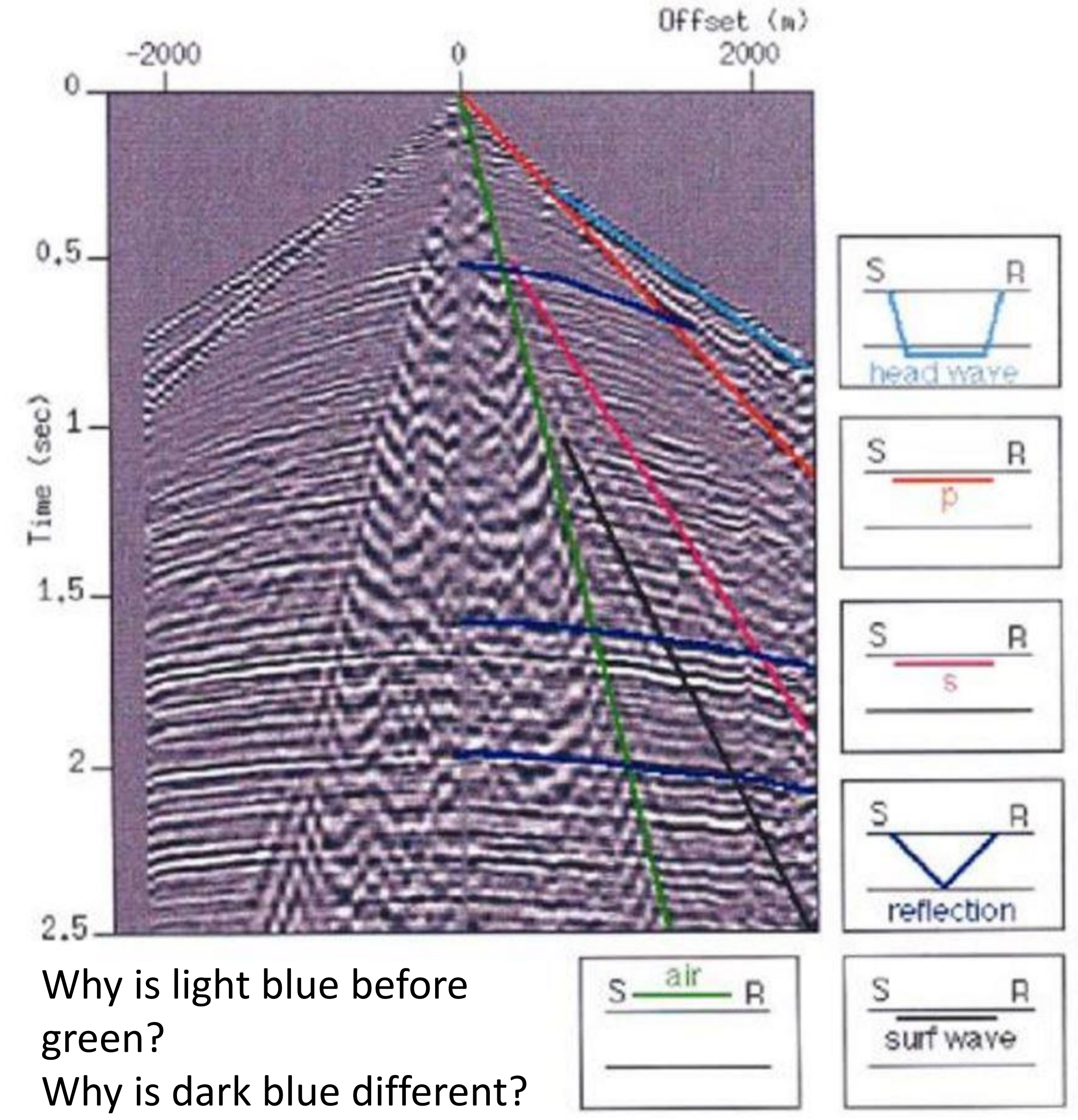
$$R_{pp}(\theta) = \frac{1}{2}(1+\tan^2\theta)\frac{\Delta Ip}{Ip} - 4\left(\frac{Vs}{Vp}\right)^2 \sin^2\theta\frac{\Delta Is}{Is} - \left[\frac{1}{2}\tan^2\theta - 2\left(\frac{Vs}{Vp}\right)^2 \sin^2\theta\right]\frac{\Delta\rho}{\rho}$$

So, Isotropic PP-reflection depends on ***Vp, Vs and density***!

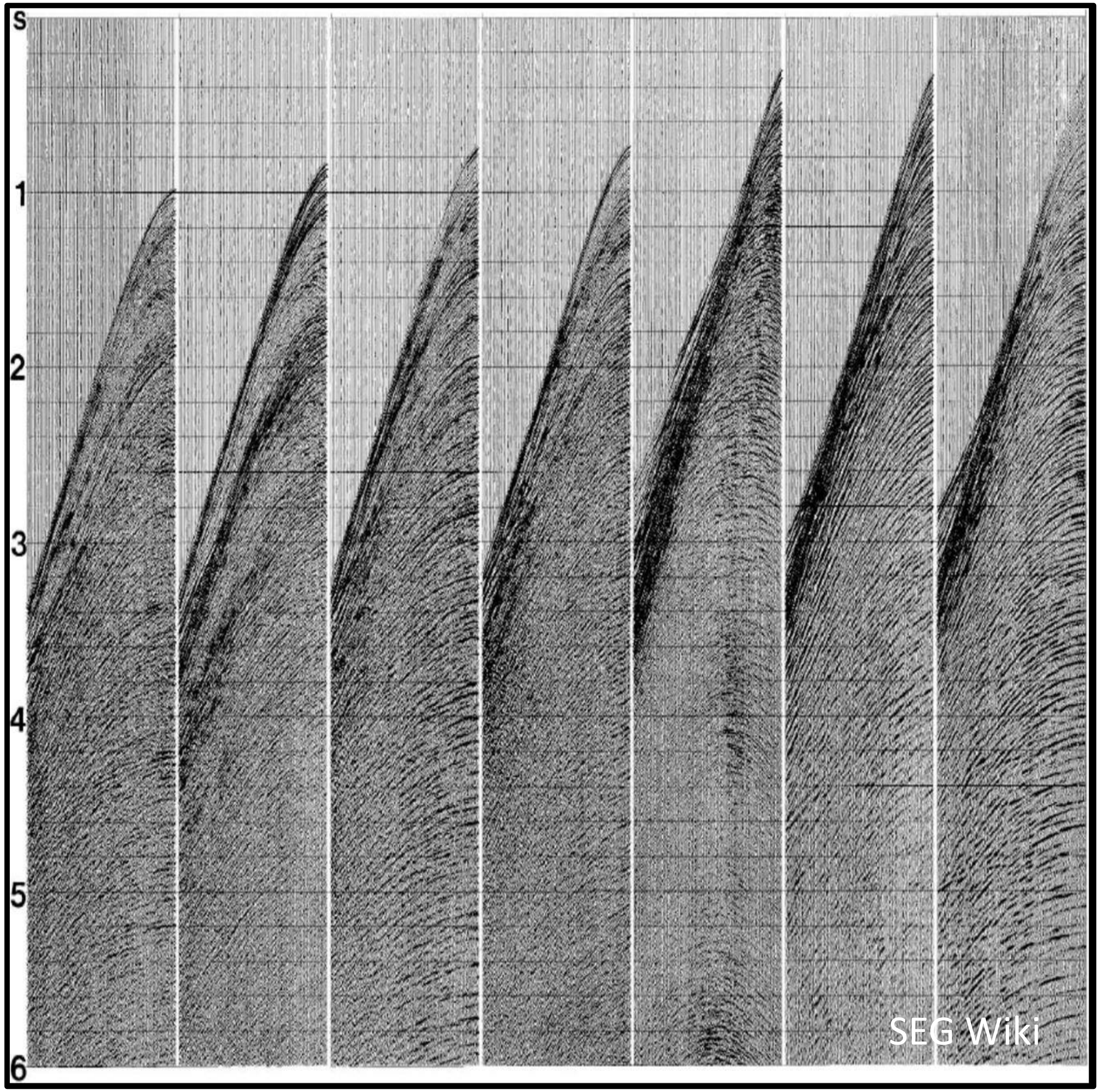
Note: Actually very hard to get third term: (Δρ/ρ)….

($\theta = \alpha_{1p}$)

Seismic Data – Land/Marine



Why is light blue before green?
Why is dark blue different?



AVO Amplitude Attributes – Pre-stack Seismic

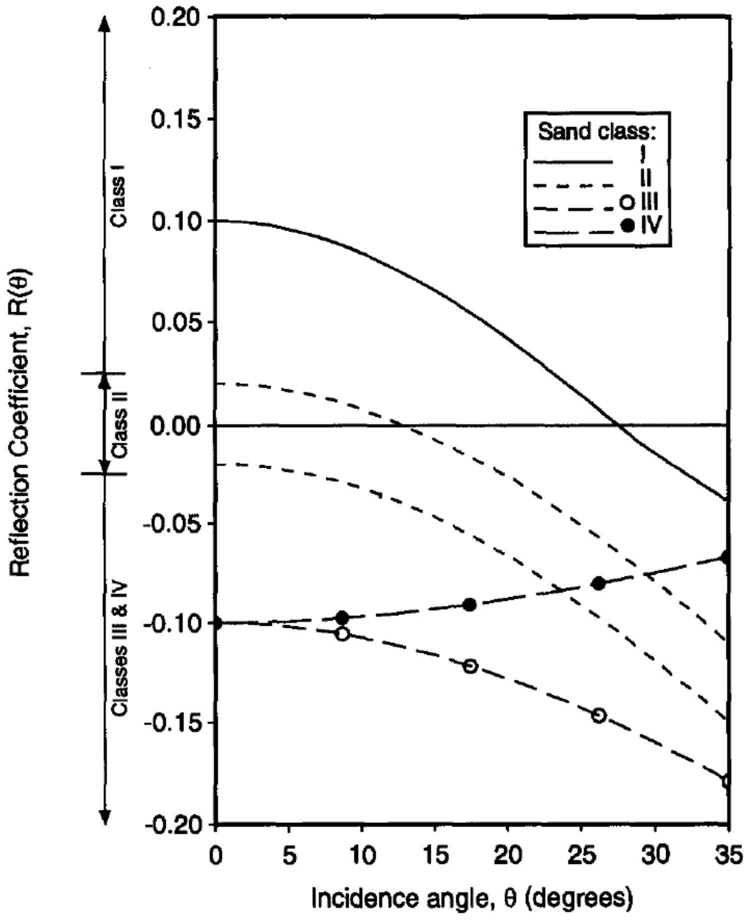
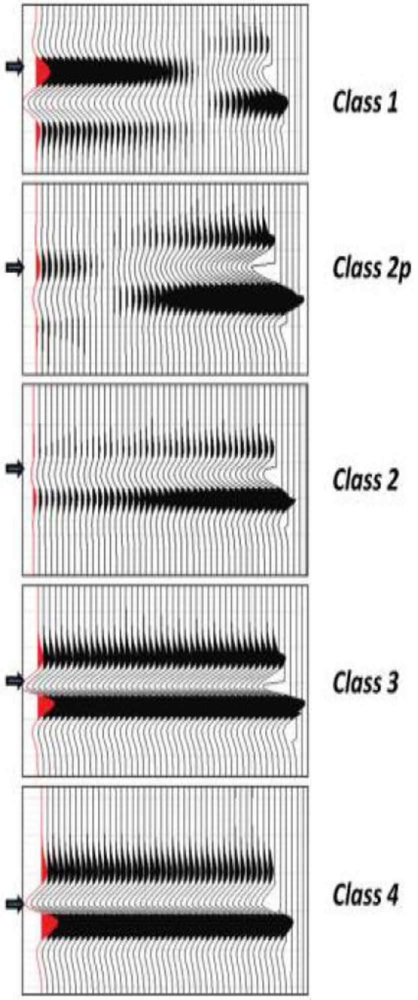


FIG. 7. Plane-wave reflection coefficients at the top of each Rutherford and Williams (1989) classification of gas sand. Class IV sands, not discussed by Rutherford and Williams, have a negative normal-incidence reflection coefficient, but decrease in amplitude magnitude with offset.



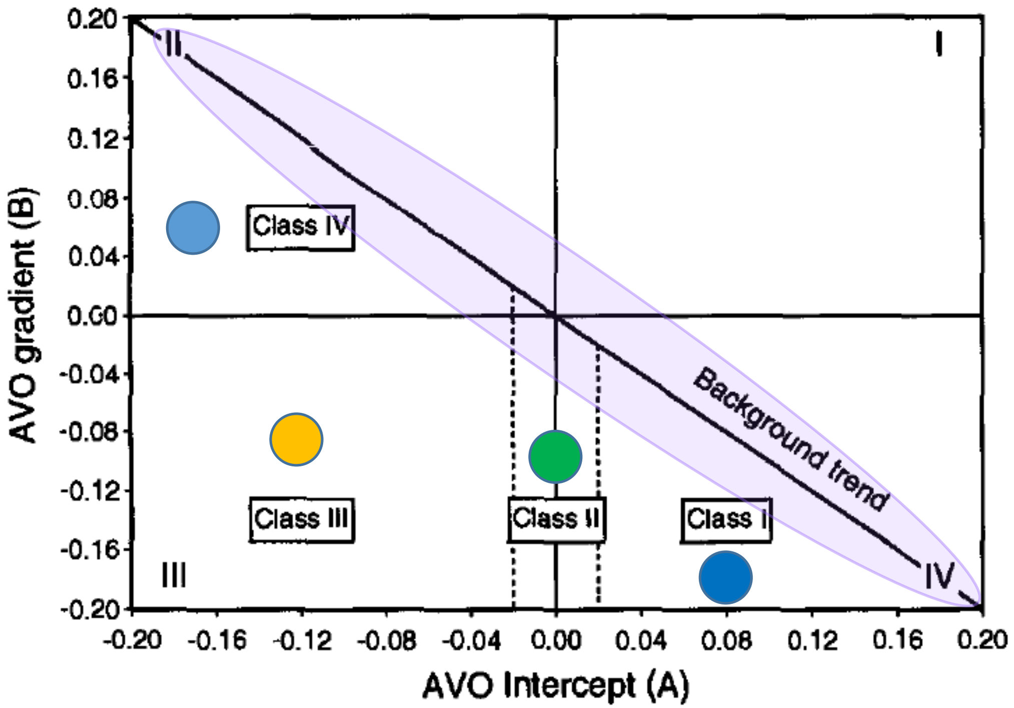


FIG. 6. AVO intercept (A) versus gradient (B) crossplot showing four possible quadrants. For a limited time window, brine-saturated sandstones and shales tend to fall along a well-defined background trend. Top of gas-sand reflections tend to fall below the background trend, whereas bottom of gas-sand reflections tend to fall above the trend. Augmented Rutherford and Williams (1989) gas sand classes are also indicated for reference.

Castagna et al, 1998
Roden et al, 2014

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Roden et al, 2015

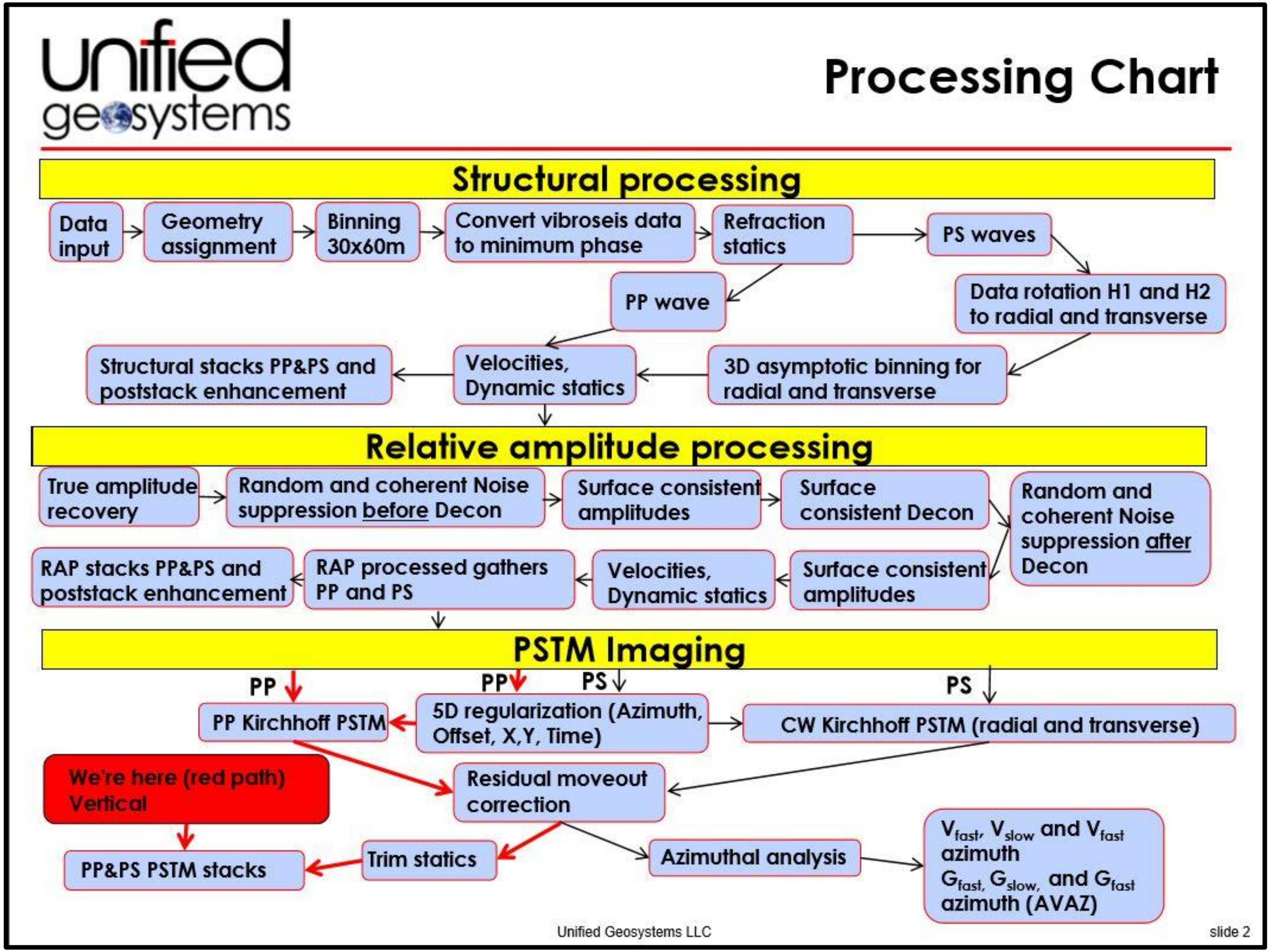
Strategy for analysis:

- Compute several ***key*** attributes right away on multiple horizons (top, base, etc) or as 3-D volume:
  - Time/depth structure (map)
  - RMS amplitude in a window (map)
  - Reservoir thickness (map)
  - Quadrature (volume)
  - Coherency (volume)

  - Wedge model using up-scaled well logs (if you have a well)
  - AVO Cross-plots (if you have pre-stack data)

- After you understand these basic attributes, choose more case specific attributes to generate

Seismic Data Processing - Land



Galikeev, 2017