Preliminary Analysis of Pore Pressures in Atlantis Field Utilizing P-SV Velocities from Multicomponent Node Data

Presented by Jeff Kao

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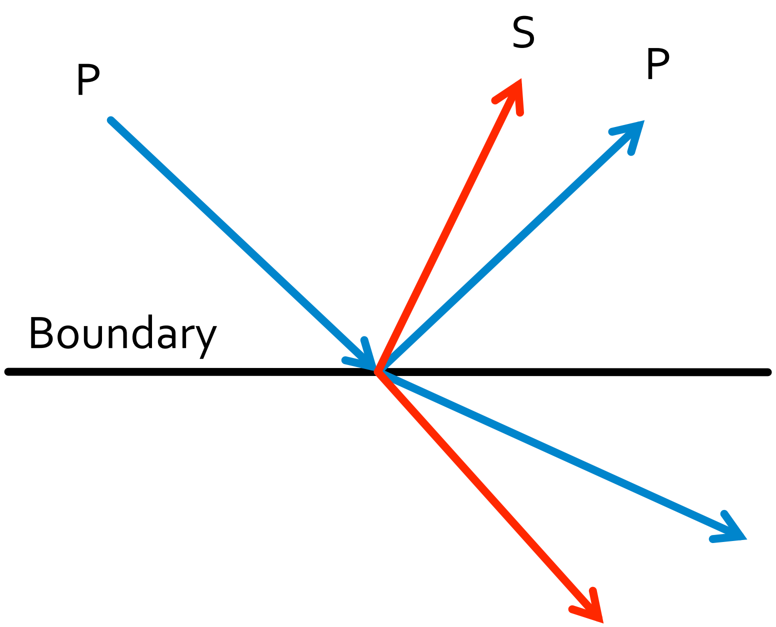
Outline

- Objectives
- Atlantis project introduction
- Overview of methodology
- Results
- Summary
- Future work

Objectives

- First objective: Analyze 4C data
- Second objective: Condition data for P and S wave velocity analysis
- Third objective: Application of velocity values to pore pressure estimation

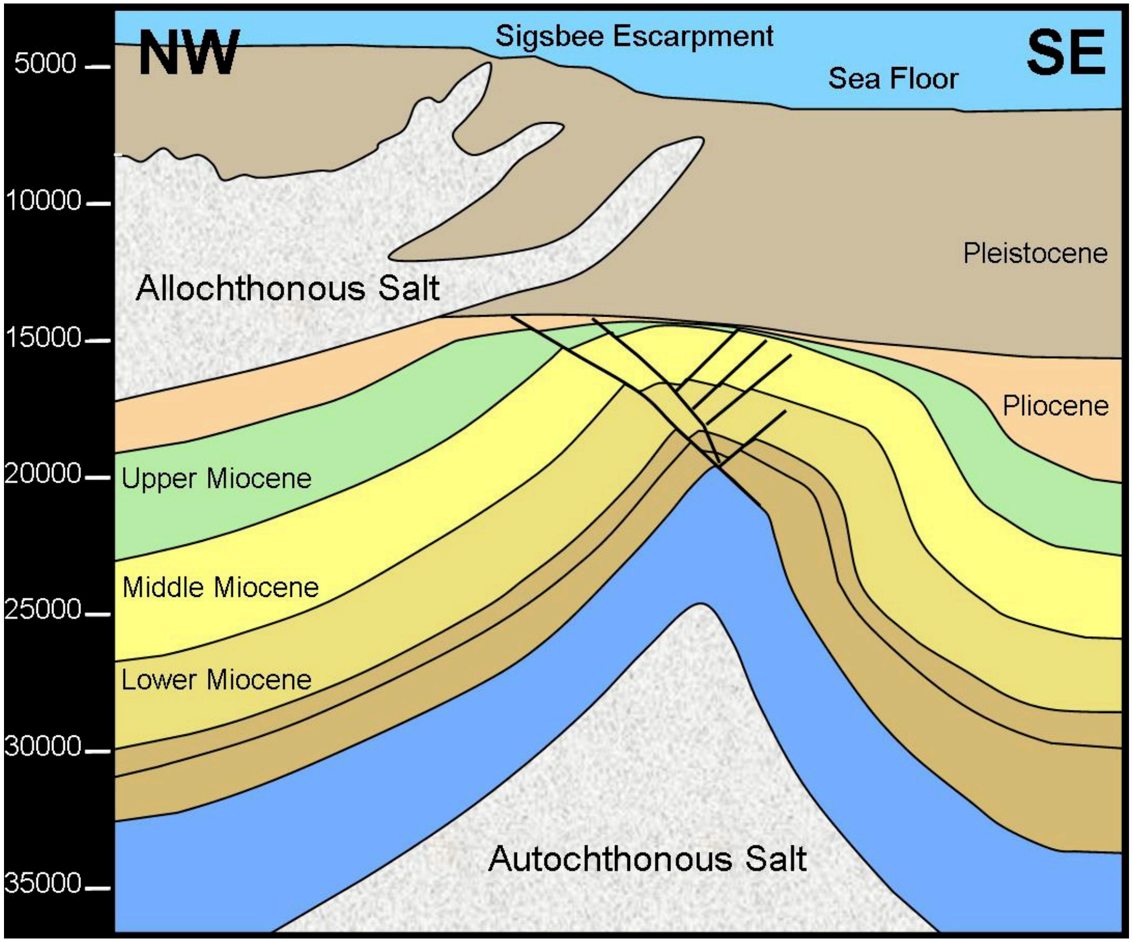
Atlantis Project Introduction



- Observe both P-P and P-SV waves velocities
- Shear waves are more sensitive to pressure than P waves
- Use observed results to analyze the geopressures in the shallow subsurface
- Water depths of approximately 2000 m in Gulf of Mexico
- Analyzing shallow subsurface velocities

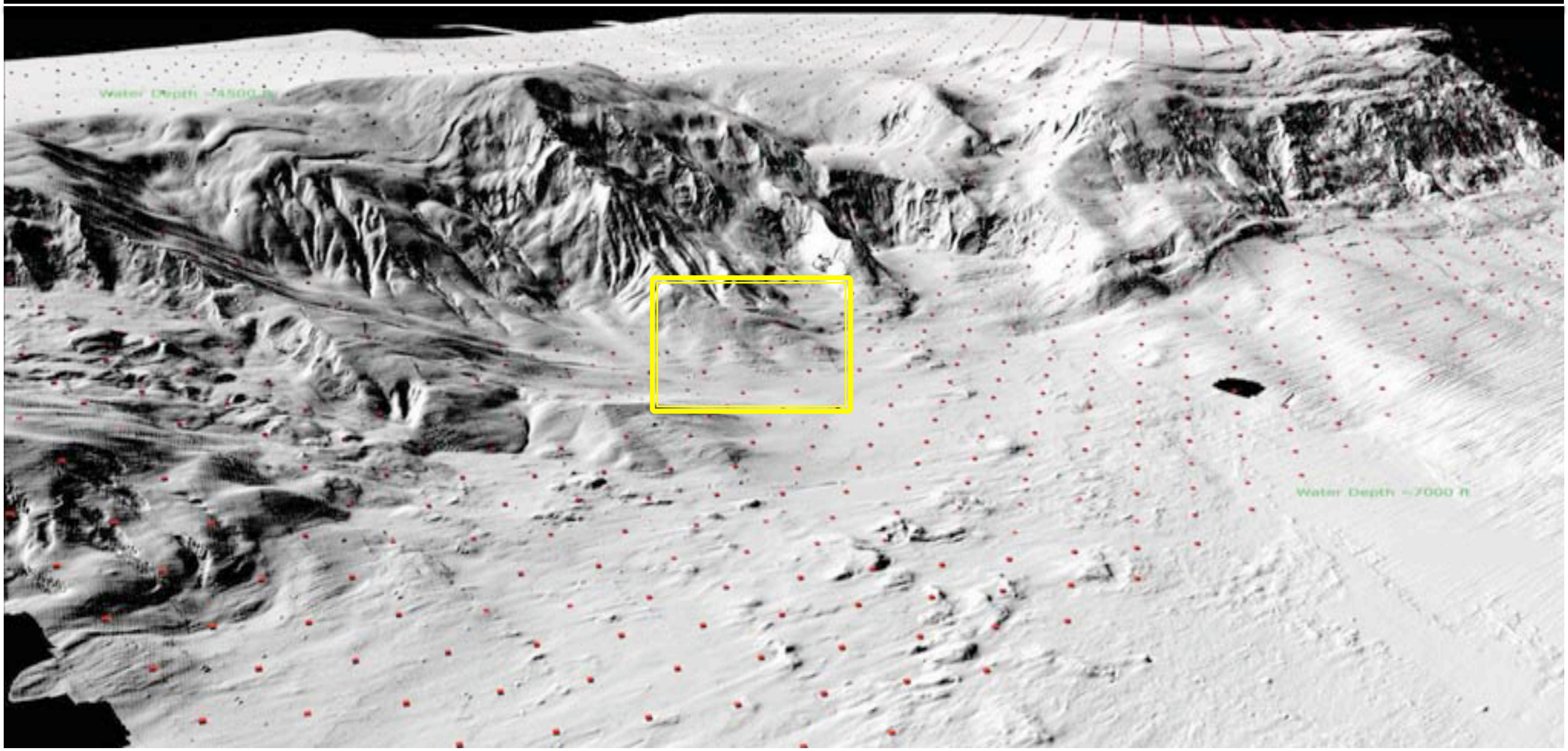
Beaudoin et al., 2007

Atlantis Project Introduction



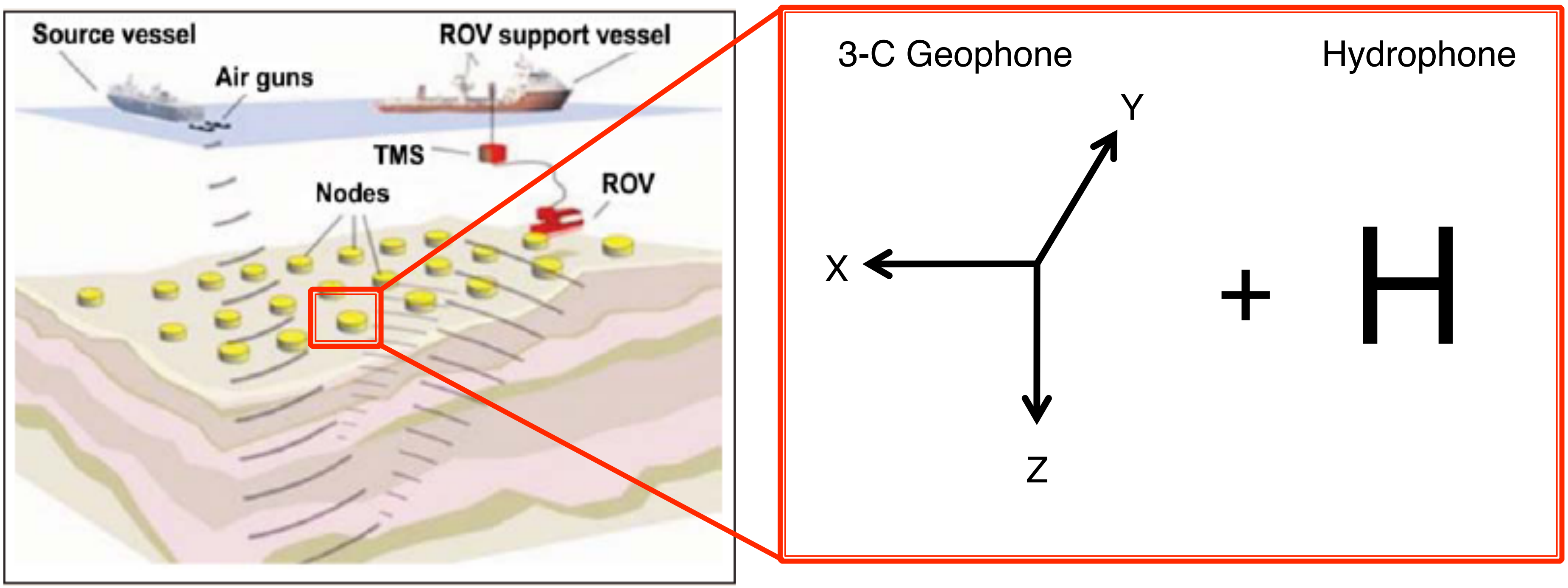
Beaudoin et al., 2007

Atlantis Seafloor



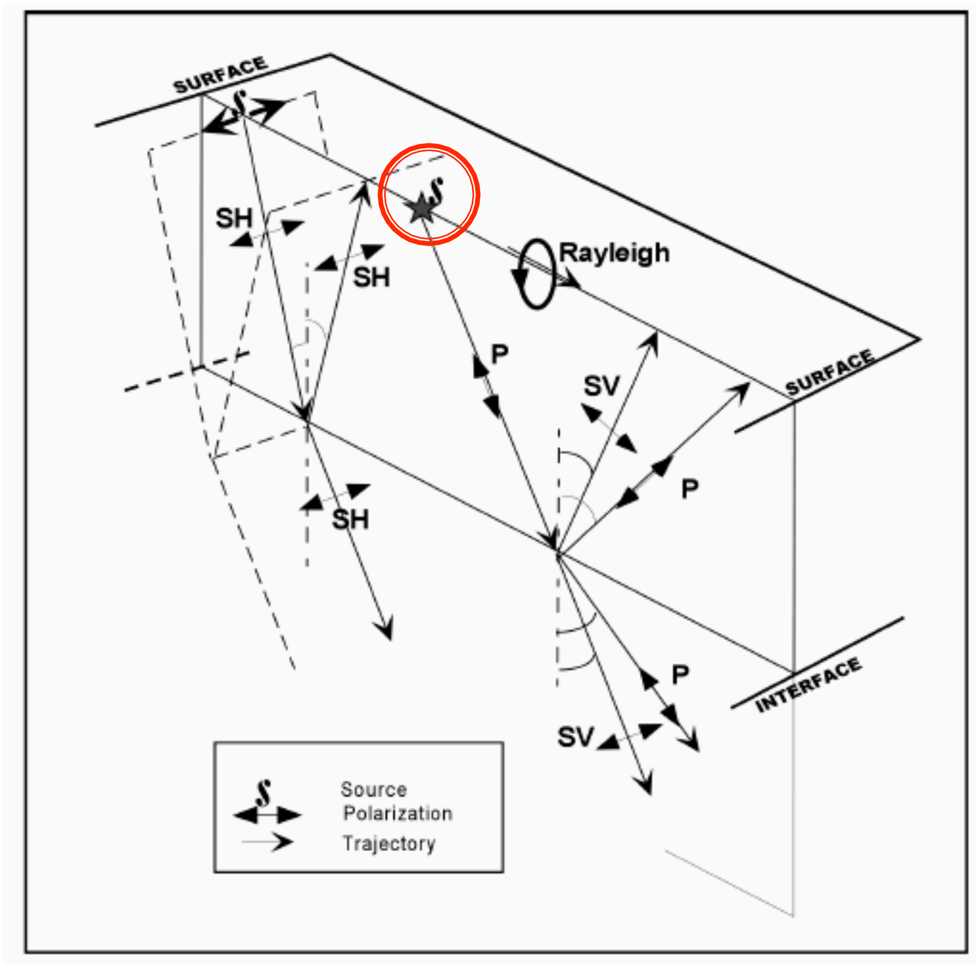
Beaudoin et al., 2007

Multicomponent Node

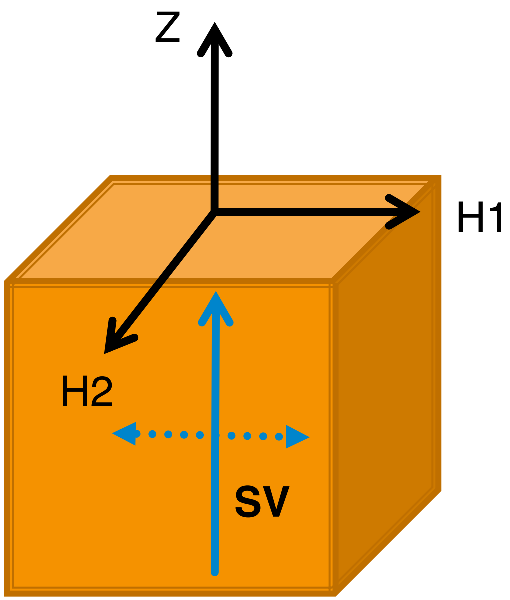


Beaudoin et al., 2007

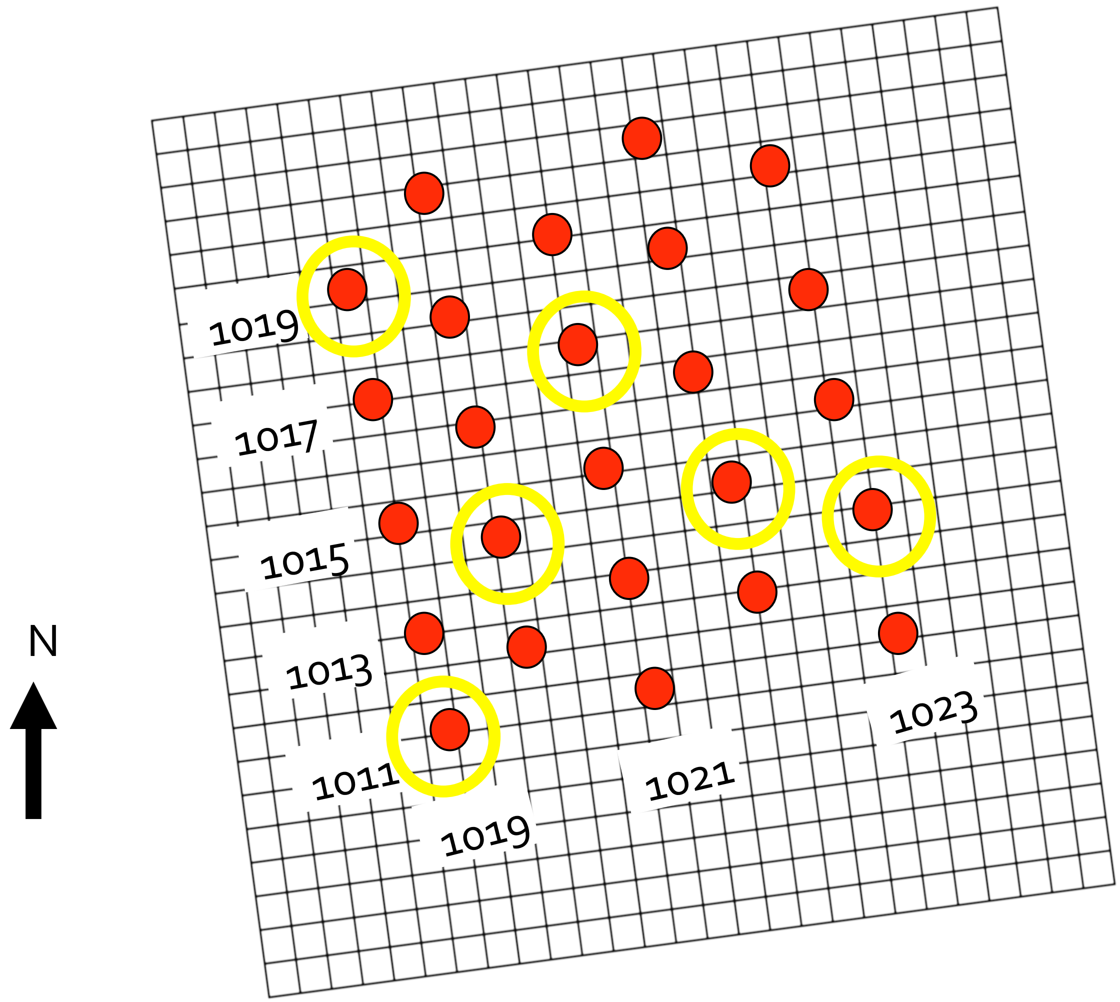
Recording P and S Waves



Guevara, 2000



Nodes Used



6 Nodes:
1019_1011
1020_1014
1021_1017
1023_1013
1022_1014
1019_1019

Methodology Overview

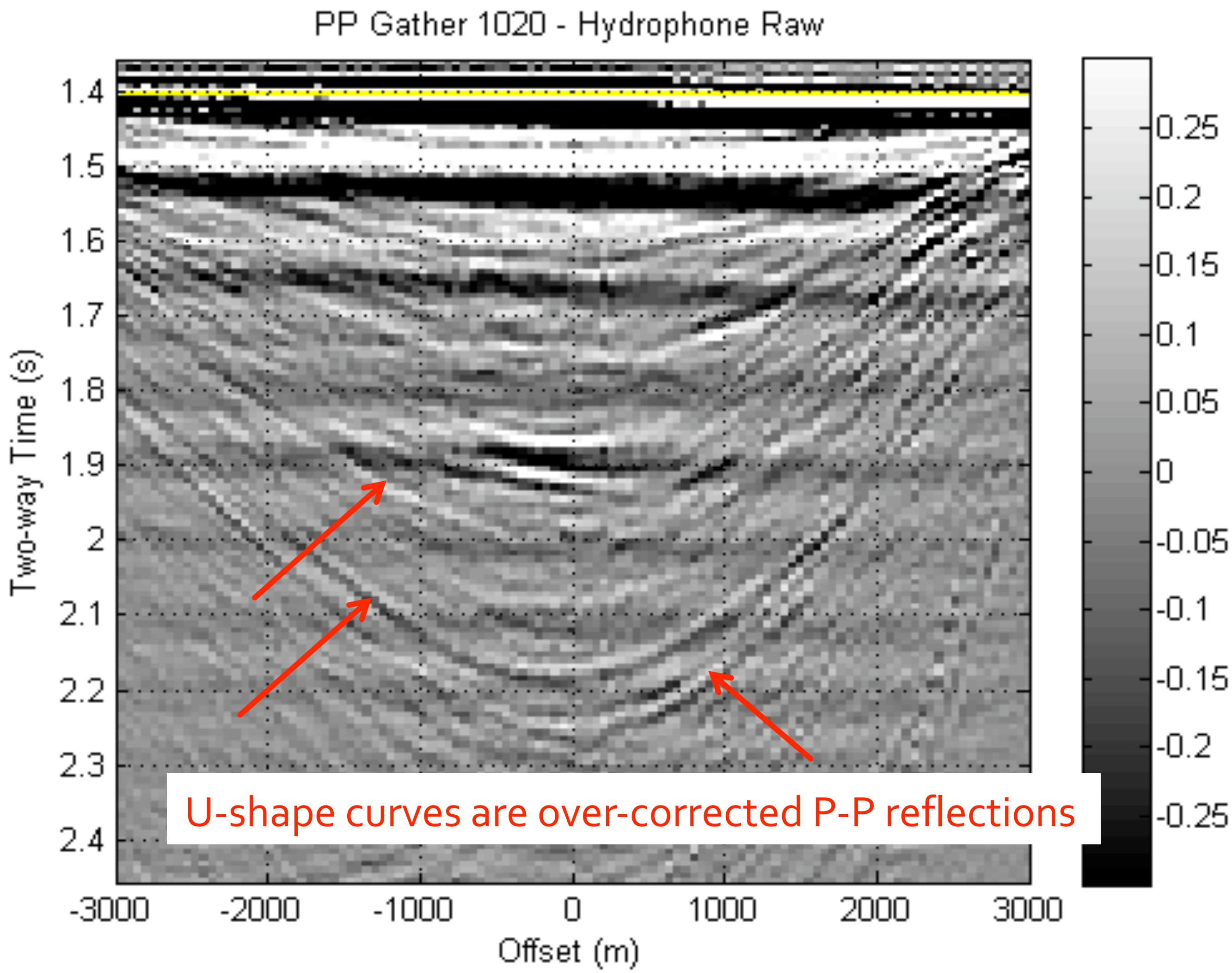
Data Conditioning

- Rotate raw horizontal components into radial and transverse orientations
- Wavefield separation
- Deconvolution of up going and down going waves
- Velocity analysis using ray-tracing approach

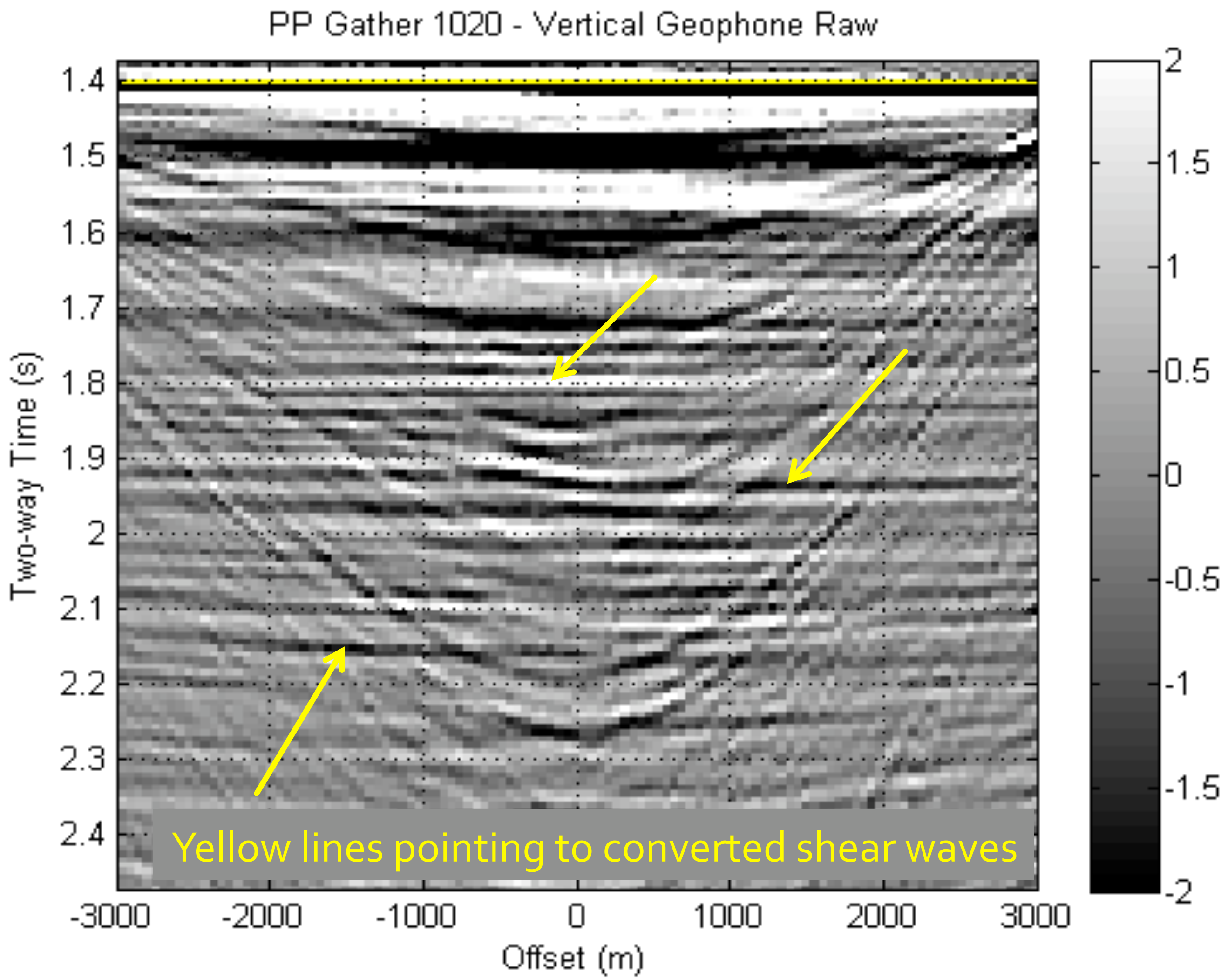
Interpretation

- Solve for σ_{obs} using Eaton's modified equation

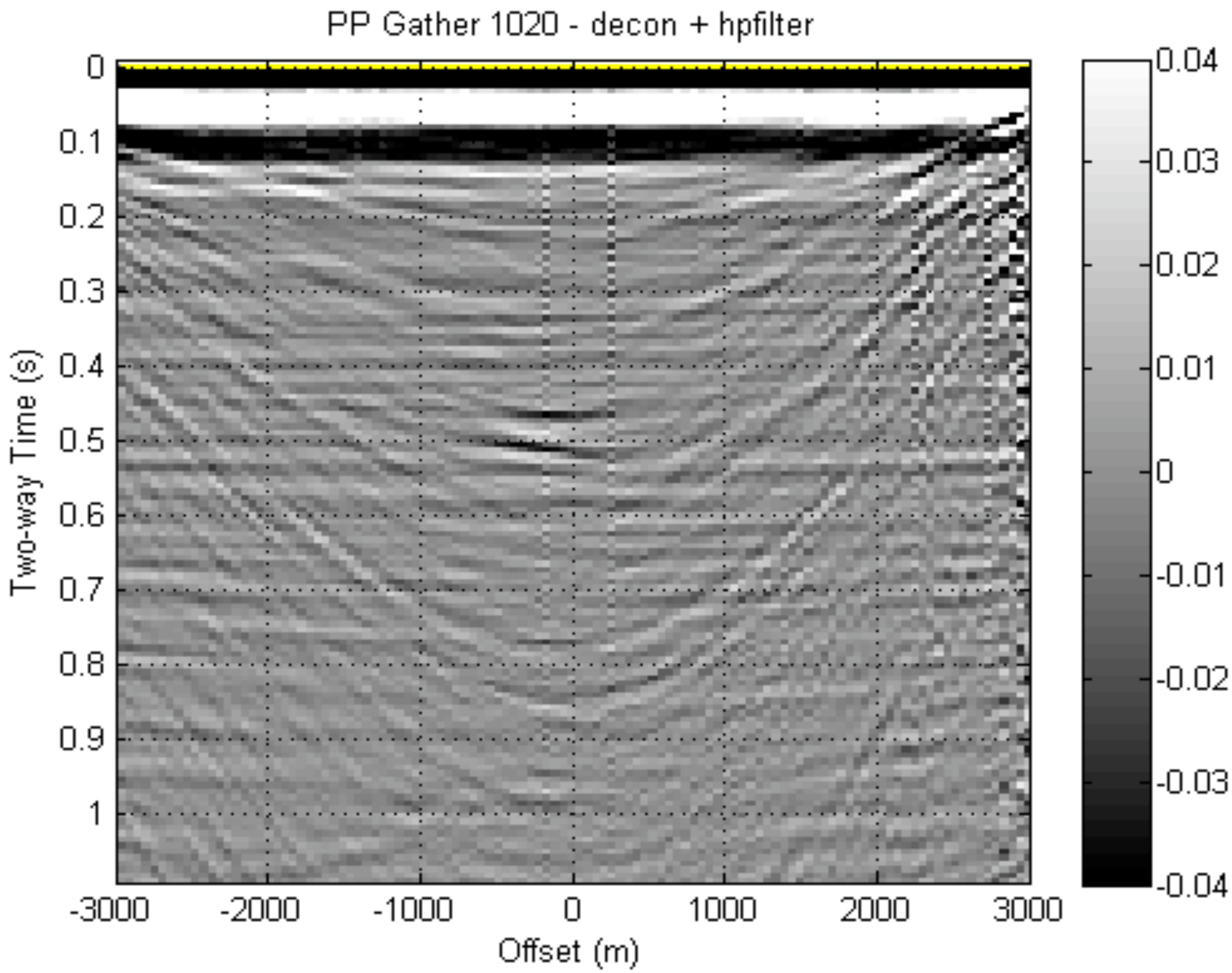
Raw Hydrophone Gather with Seafloor Flattened, No Shift in Time



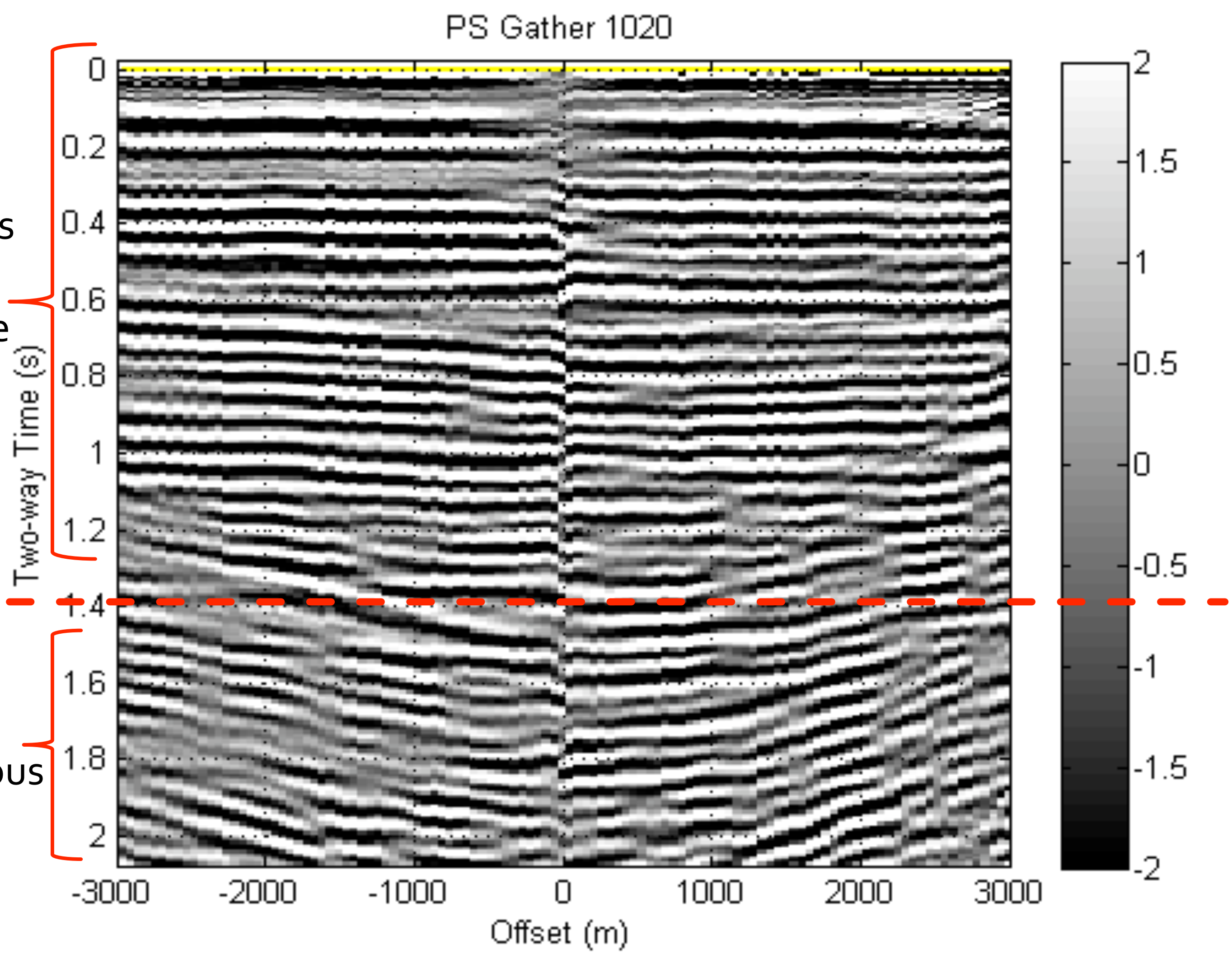
Raw Vertical Geophone Gather with Seafloor Flattened, No Shift in Time



Deconvolution and High Pass Freq. Filter Gather with Seafloor Flattened and shifted to 0 seconds



Radial Gather – Seafloor Flattened and Shifted to 0 seconds

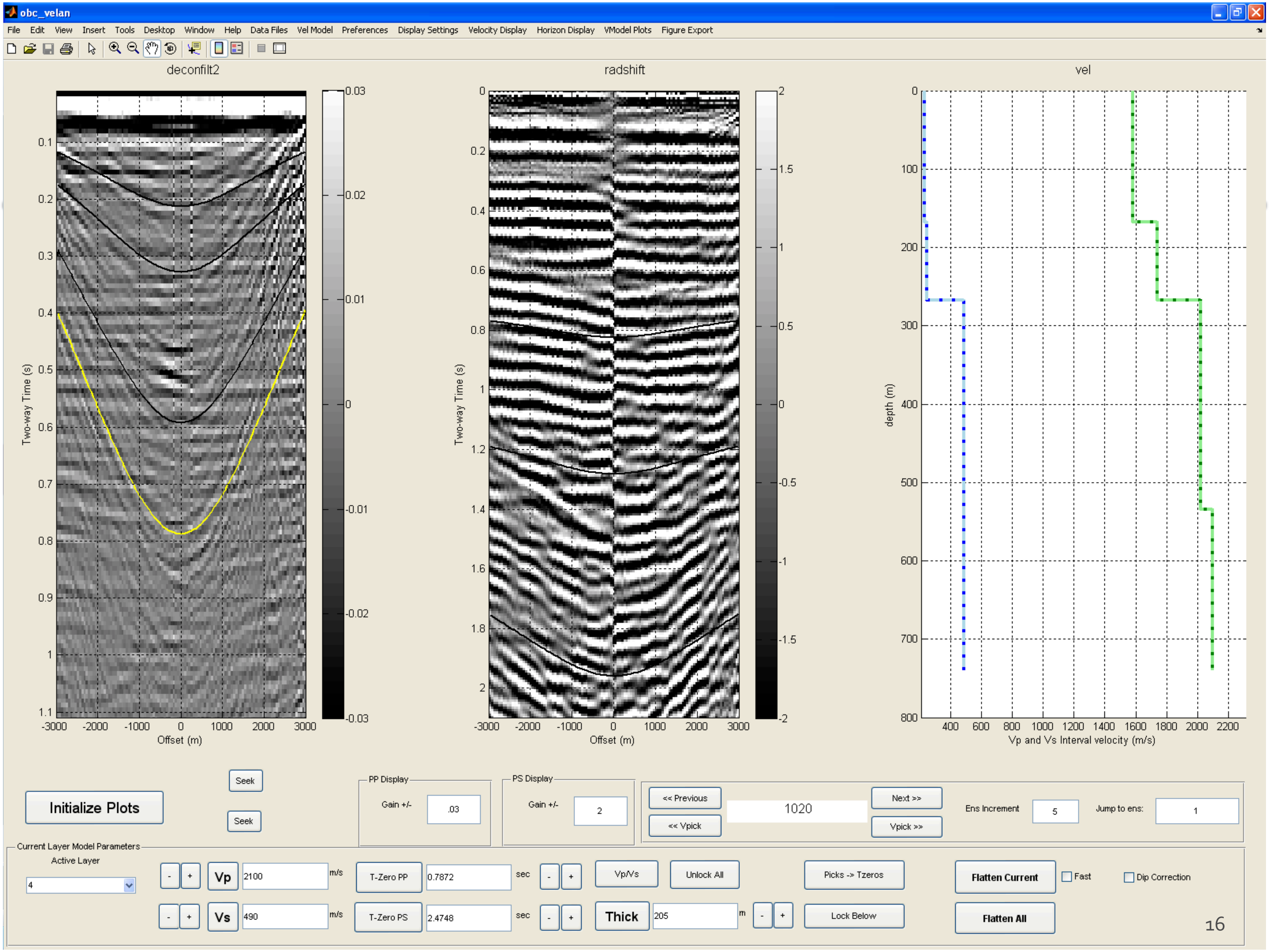


Continuous converted shear wave reflections

Reflections become discontinuous

Ray Tracing for P and S wave velocity Analysis

- User inputs a P-P and P-SV gather
- Algorithm can take in account ray path through the water column if not flattened to seafloor and shifted to 0 seconds (it will subtract the direct arrival out in the calculations)
- Start with a reflector in the P-P gather, then register the reflector to the P-SV gather; adjust values for Vp(m/s), Vs(m/s), and thickness (m) until the three parameters successfully flattens the specific reflector in both seismic gathers
- Continue process for deeper reflectors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deconfilt2
radshift
vel
Two-way Time (s)
Offset (m)
depth (m)
Vp and Vs Interval velocity (m/s)
Initialize Plots
Seek
Seek
PP Display
Gain +/-
.03
PS Display
Gain +/-
2
<< Previous
1020
Next >>
<< Vpick
Vpick >>
Ens Increment
5
Jump to ens:
1
Current Layer Model Parameters
Active Layer
4
Vp
2100
m/s
Vs
490
m/s
T-Zero PP
0.7872
sec
T-Zero PS
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sec
Vp/Vs
Unlock All
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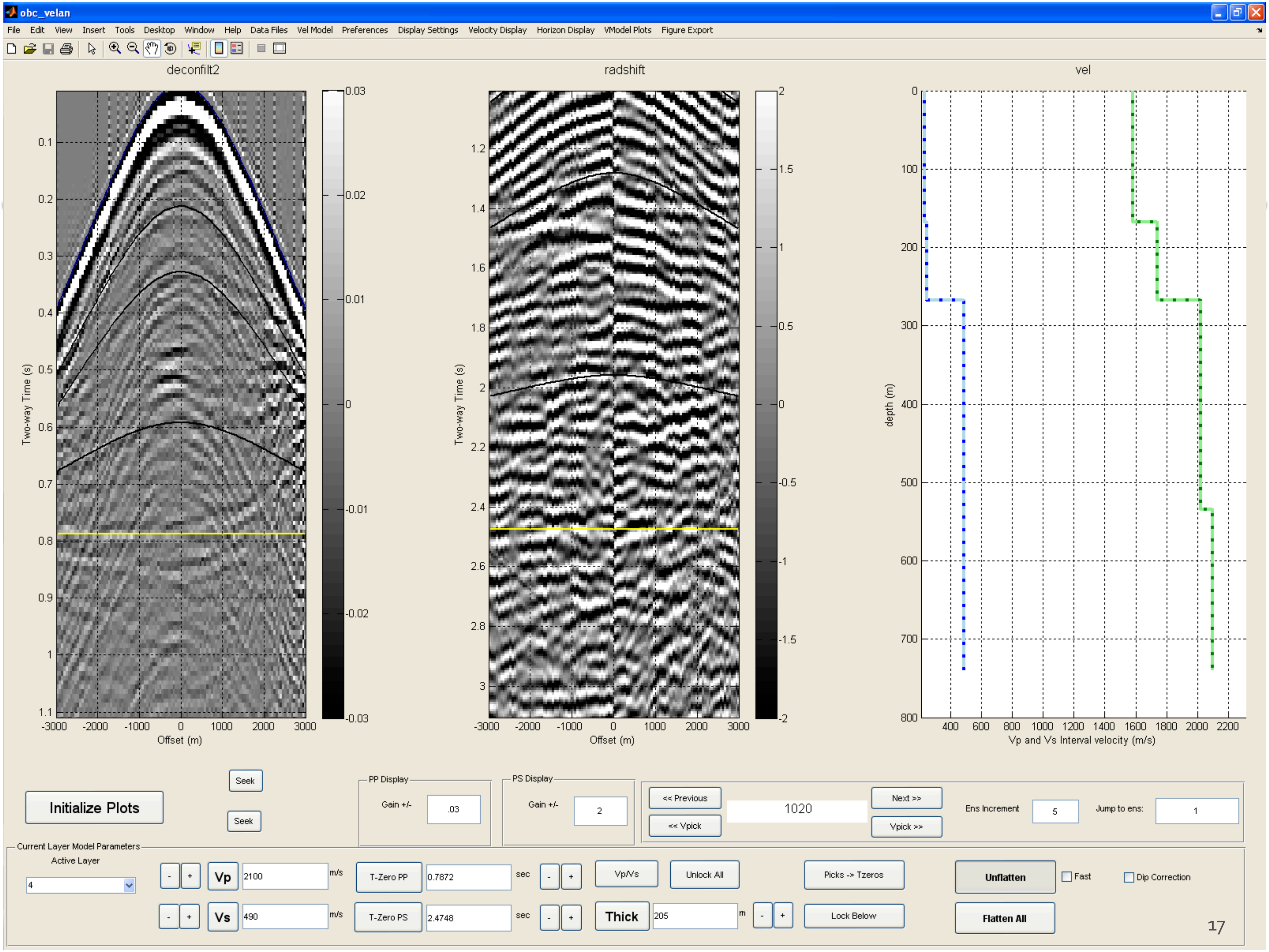
Picks -> Tzeros
Lock Below
Flatten Current
Fast
Dip Correction
Flatten All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Unflatten
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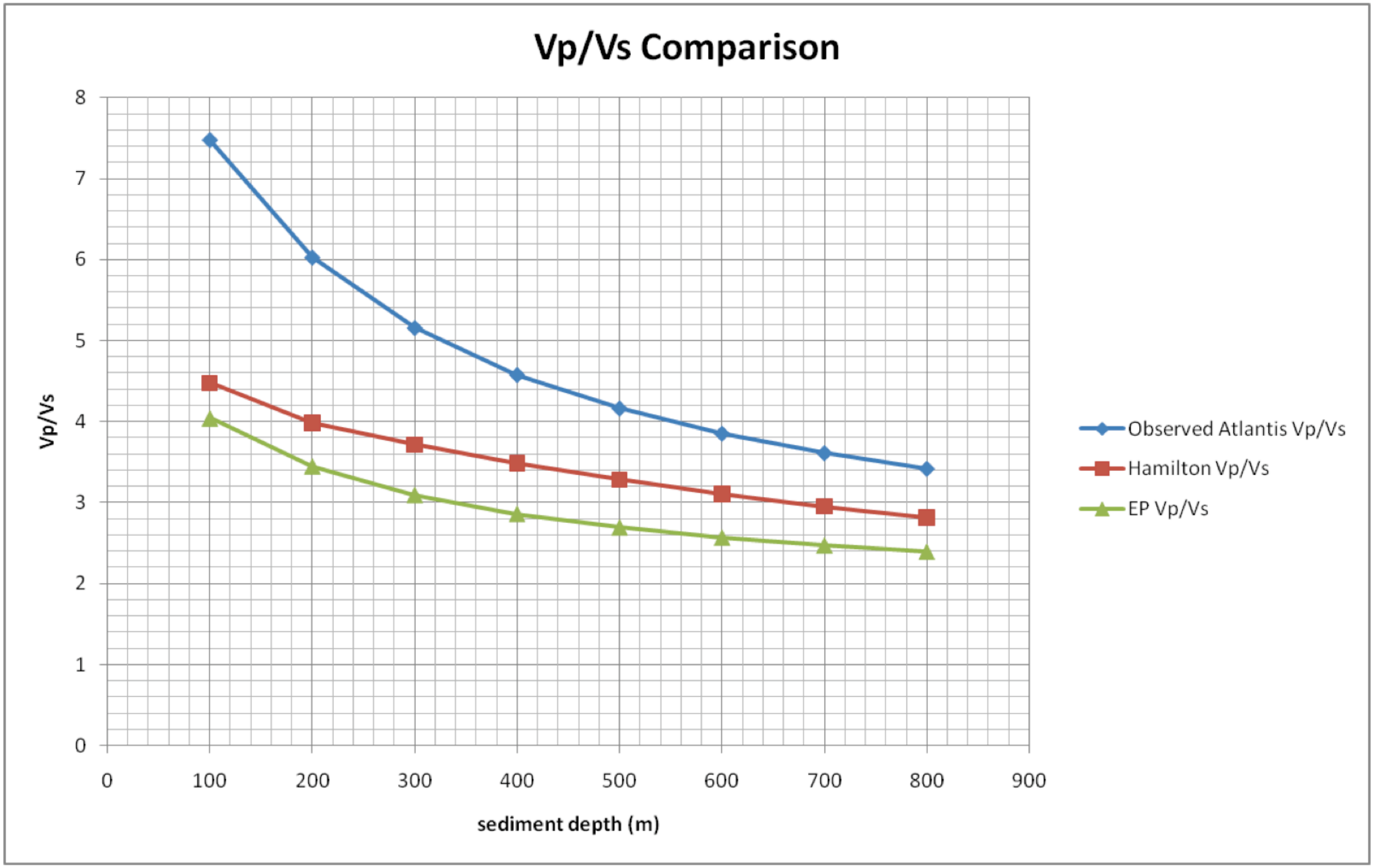
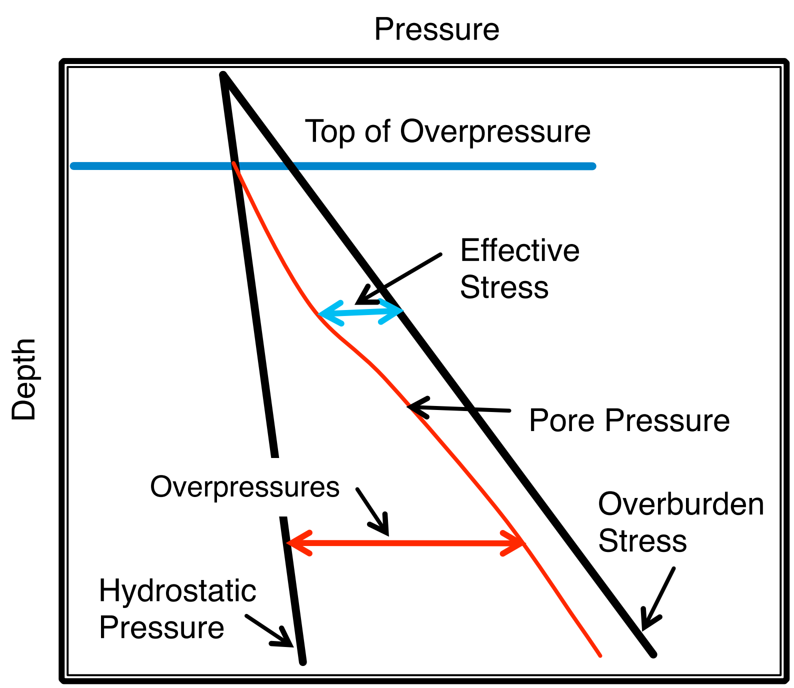
Dip Correction
Flatten All

Vp/Vs Comparison



Definitions



Pore pressure – pressure of fluid in the pore space of the rock

Hydrostatic pressure – the normal, predicted pressure by a column of water from sea level to a given depth

Overburden pressure – pressure exerted by all overlying material, both solid and fluid

Overpressure – subsurface pore pressure that is abnormally high, exceeding hydrostatic pressure at a given depth

Effective pressure – difference between overburden pressure and pore pressure

Geopressure – pressure within the Earth, or formation pressure

Bruce and Bowers, 2002

Eaton's Modified Equation

$$\left(\frac{V_{ps,obs}}{V_{ps,n}}\right)^{Eps} = \left(\frac{\sigma_{obs}}{\sigma_n}\right)$$

$V_{ps,obs}$ = observed P-S wave velocity
$V_{ps,n}$ = velocity of P-S wave velocity in normal conditions
E_{ps} = Eaton's empirical exponent, using 2.6
σ_{obs} = observed effective stress
σ_n = effective stress in normal conditions

If $\sigma_{obs} < \sigma_n$, then there is evidence of overpressure

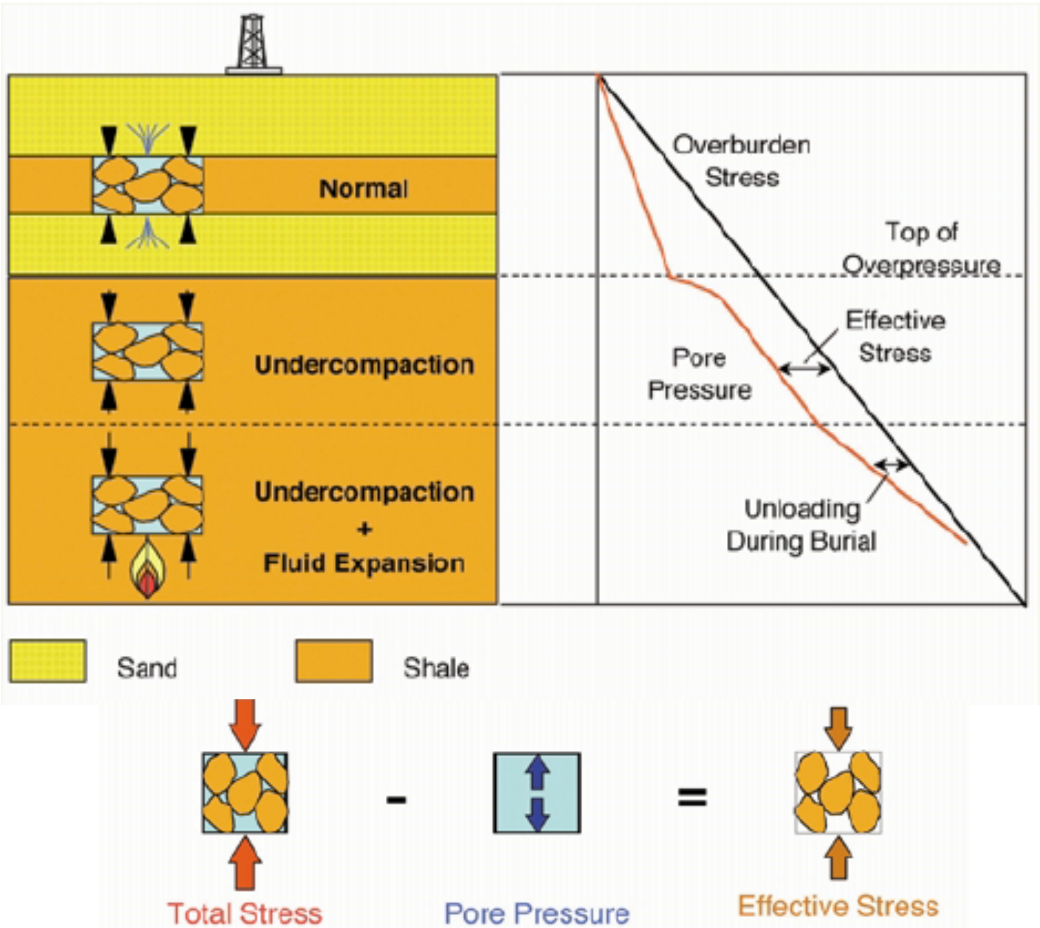
Ebrom et al., 2004

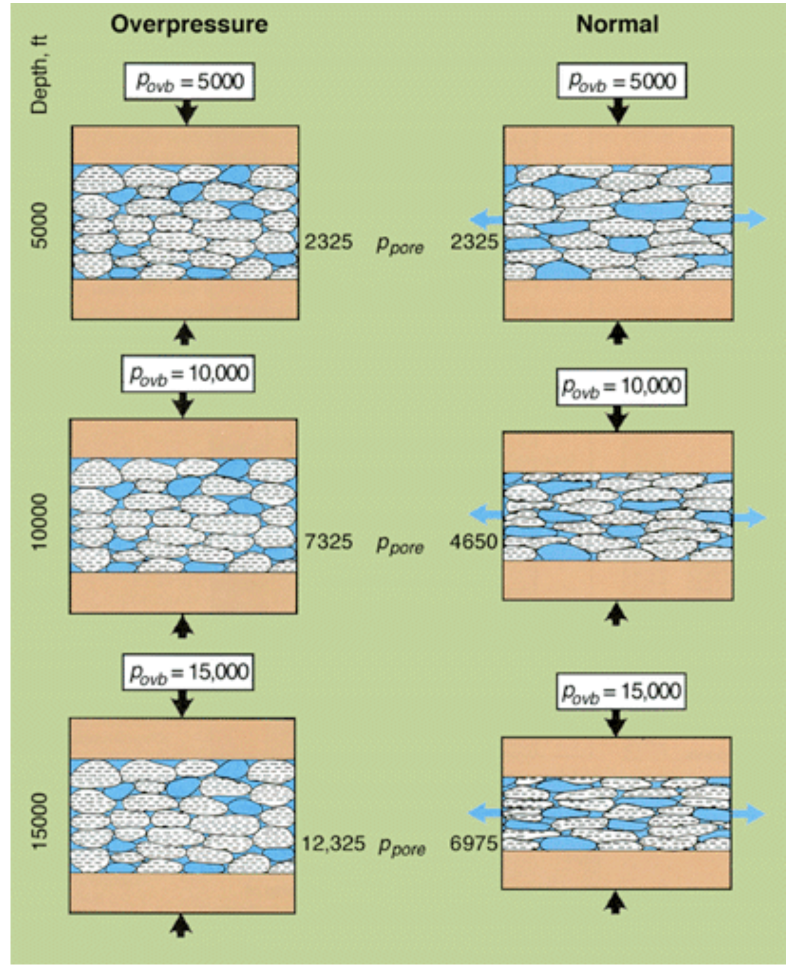
Overpressure Causes

- Undercompaction - low permeability prevents pore fluids from escaping as rapidly as pore space tries to compact
- Fluid expansion – rock matrix constraining the pore fluid as the fluid tries to increase in volume
- Lateral transfer – sealed interval having pore fluid pumped in from another higher pressure zone
- Tectonic loading – trapped pore fluid squeezed by tectonically driven lateral stresses

Bruce and Bowers, 2002

Overpressure

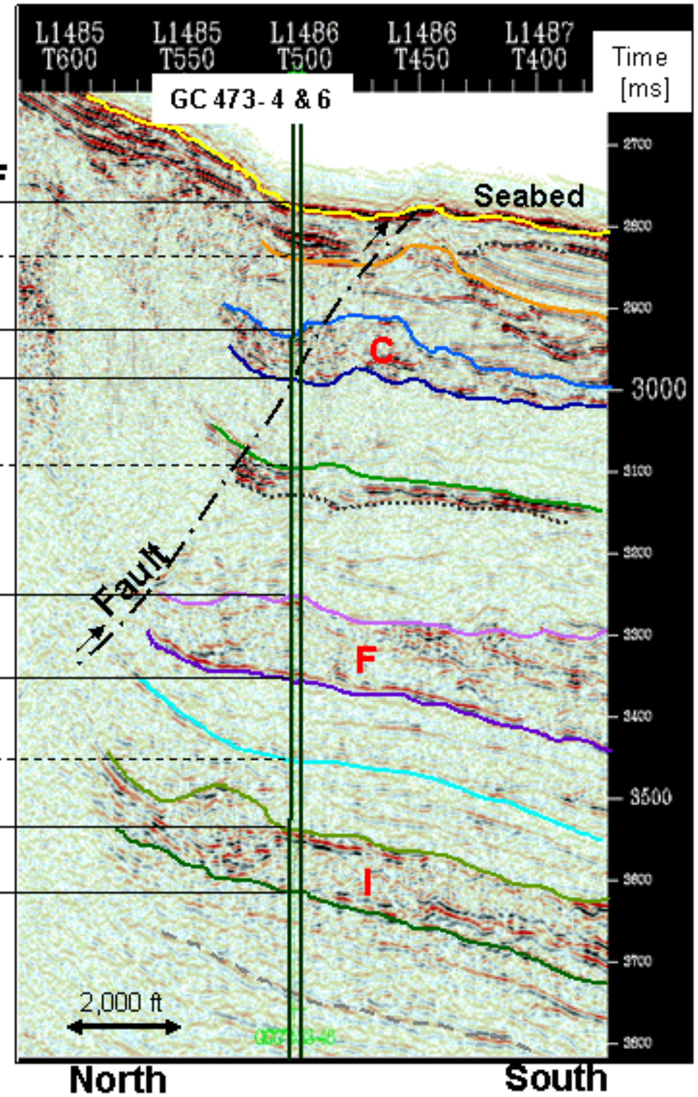




Bruce and Bowers, 2002

SLB Oilfield Glossary

Unit	Stratigraphy	Depth Ft ML	Depth Ft MD	SGA I G	SGA I SWF	SGA II G	SGA II SWF
		0	6,820				
A	Sandy Turbidites						
B	Clays and Silts	390	7,200				
C	Mass Transport Complex	570	7,500		L		L
D	Clays and Silts						
E	Sandy turbidites overlying Clays	1,365	8,260				
F	Mass Transport Complex	1,665	8,560				H
G	Clays and Silts						
H	Clays and Silts	2,270	9,085				
I	Mass Transport Complex	2,515	9,330		L		H



LEGEND

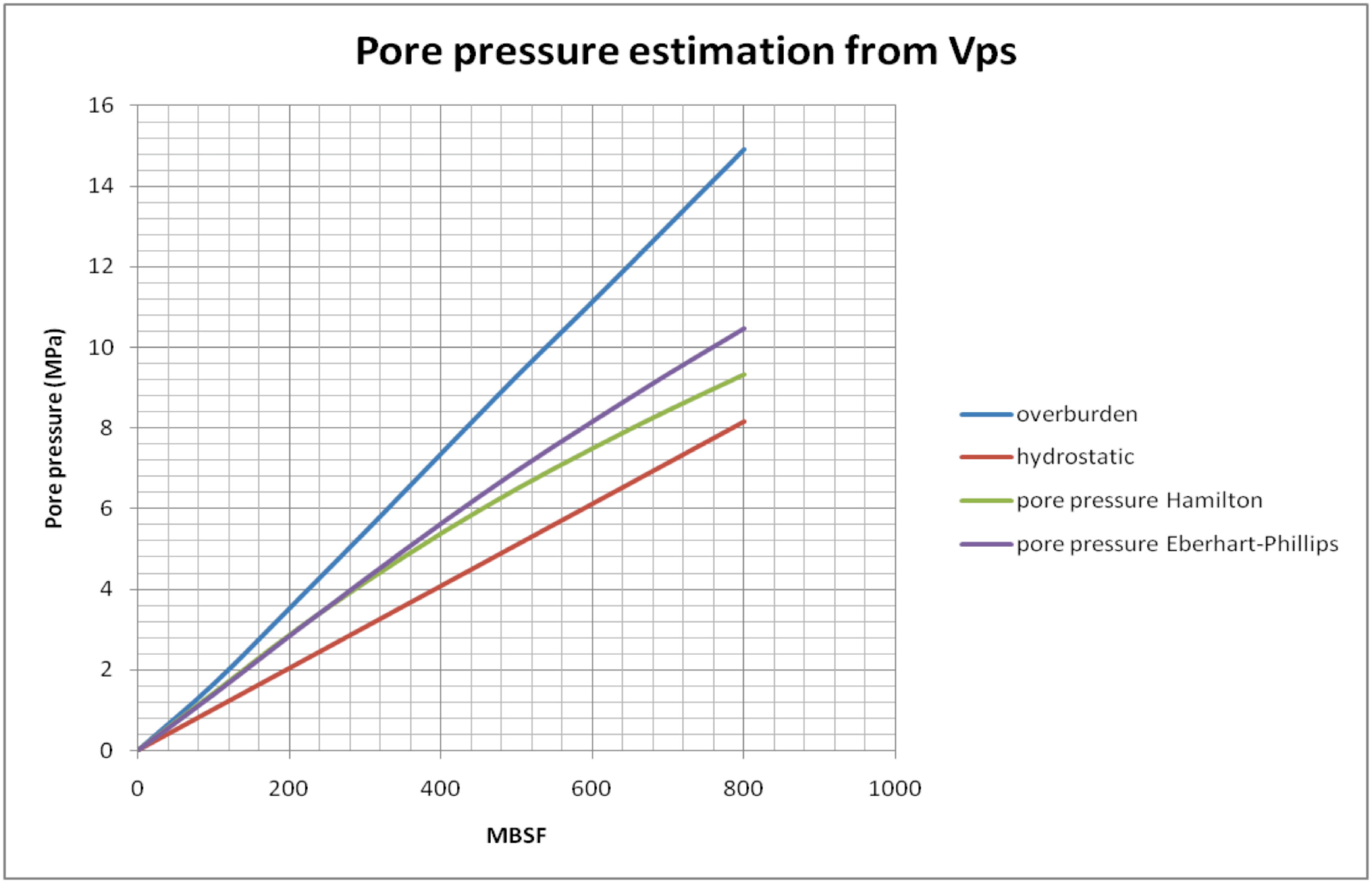
SGA I = Shallow Geohazard Assessment Pre-Appraisal Drilling
SHA II = Shallow Geohazard Assessment Post-Appraisal Drilling
G = Gas Risk
SWF = Shallow Water Flow Risk

(green) Negligible Risk · L Low Risk · M Moderate Risk · H High Risk

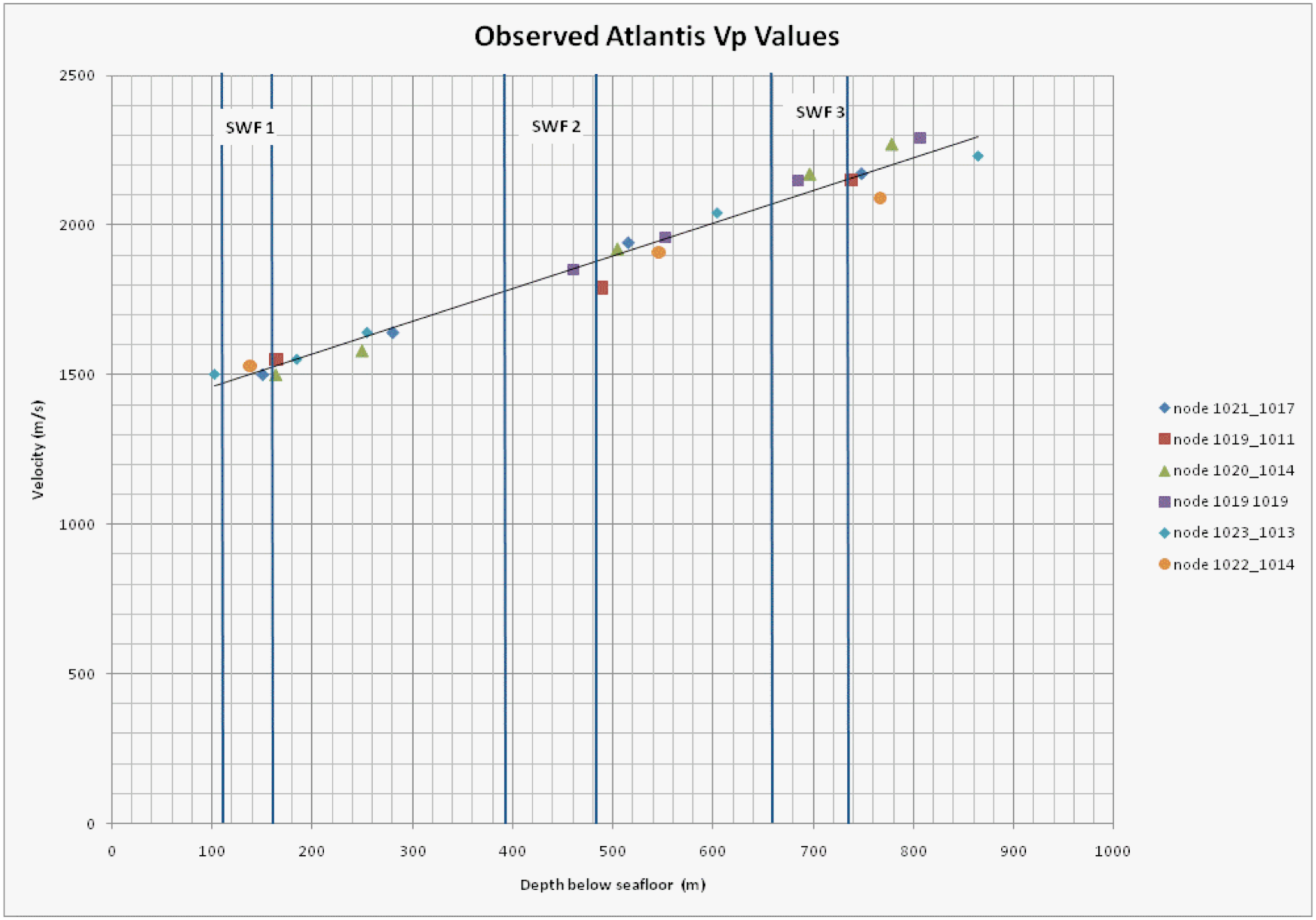
ML = Mudline · MD = Measured Depth

Mannaerts et al., 2005

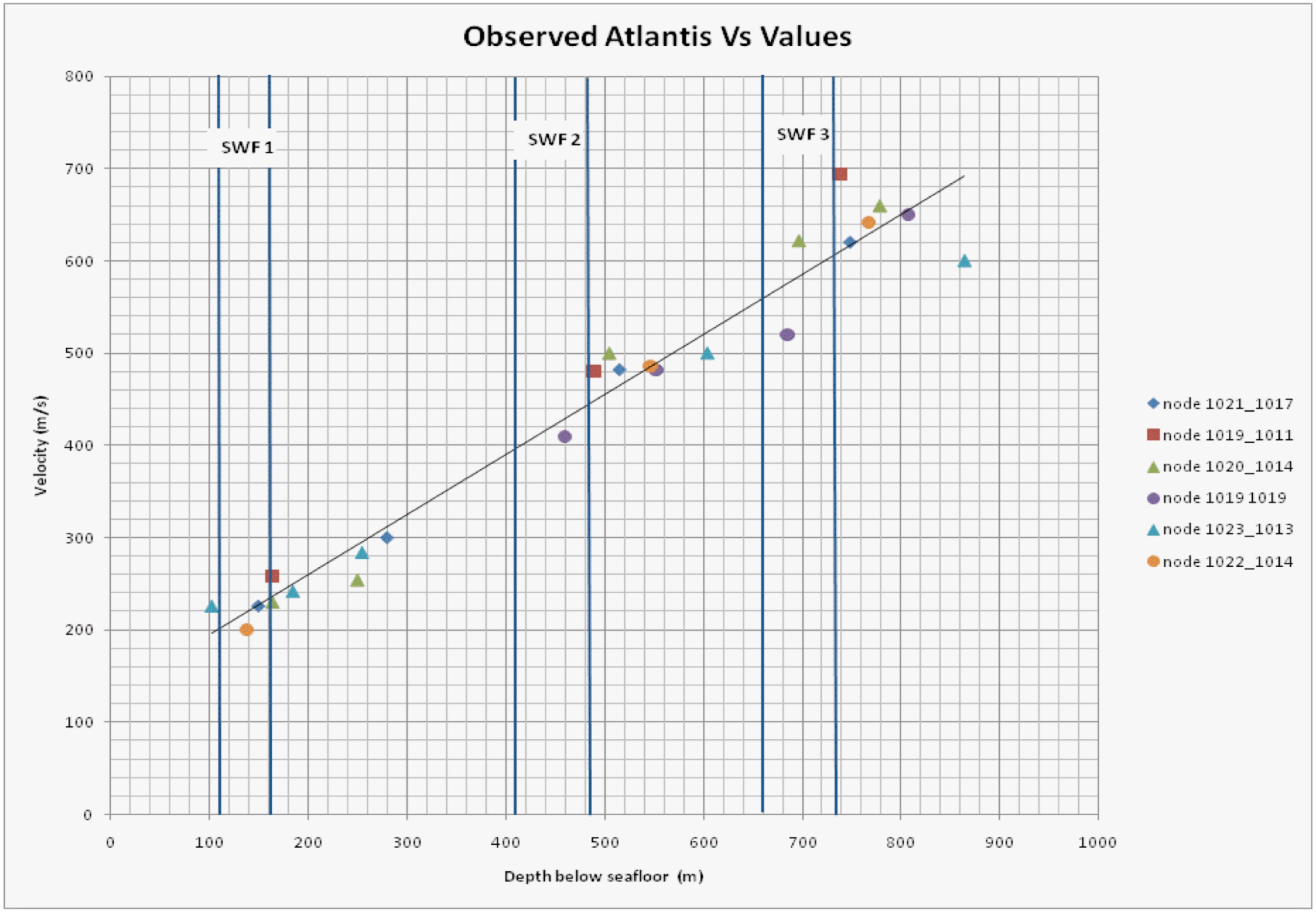
Pore pressure prediction



Plot of Estimated Vp



Plot of Estimated Vs



Summary

- Preliminary analysis shows overpressure present in the shallow sections in Atlantis Field
- Sediment gravity flows from the Sigsbee Escarpment cause the rapid sedimentation rate that in turn yield high pore pressures
- Followed methodology introduced by Backus and Murray, 2006 for imaging deepwater gas hydrate systems
- Difference from past research projects is the use of node data

Summary

- Needs further conditioning in the seismic data
- Converted waves (combination of a downgoing P-wave and reflected SV to surface) become discontinuous approx. 1.4 seconds below the seafloor
- More accurate overpressure predictions require denser velocity picks for each receiver gather

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Ebrom et al., 2004

Future Work

- Detailed processing
- May require a more suitable ray tracing algorithm for velocity analysis
- Anisotropy studies using wide-azimuth data set
- Further investigation of the pore pressure magnitudes, incorporate mudweights and well log data

Acknowledgements

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