CREWES

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Sensitivity of interval Vp/Vs analysis of seismic data

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Outline

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- Introduction
  - Area of Study
  - Input Data
- Data Interpretation
  - Horizon Interpretation
  - Vp/Vs Analysis
- Sensitivity analysis
  - Synthetic model
- Conclusions
- Acknowledgements

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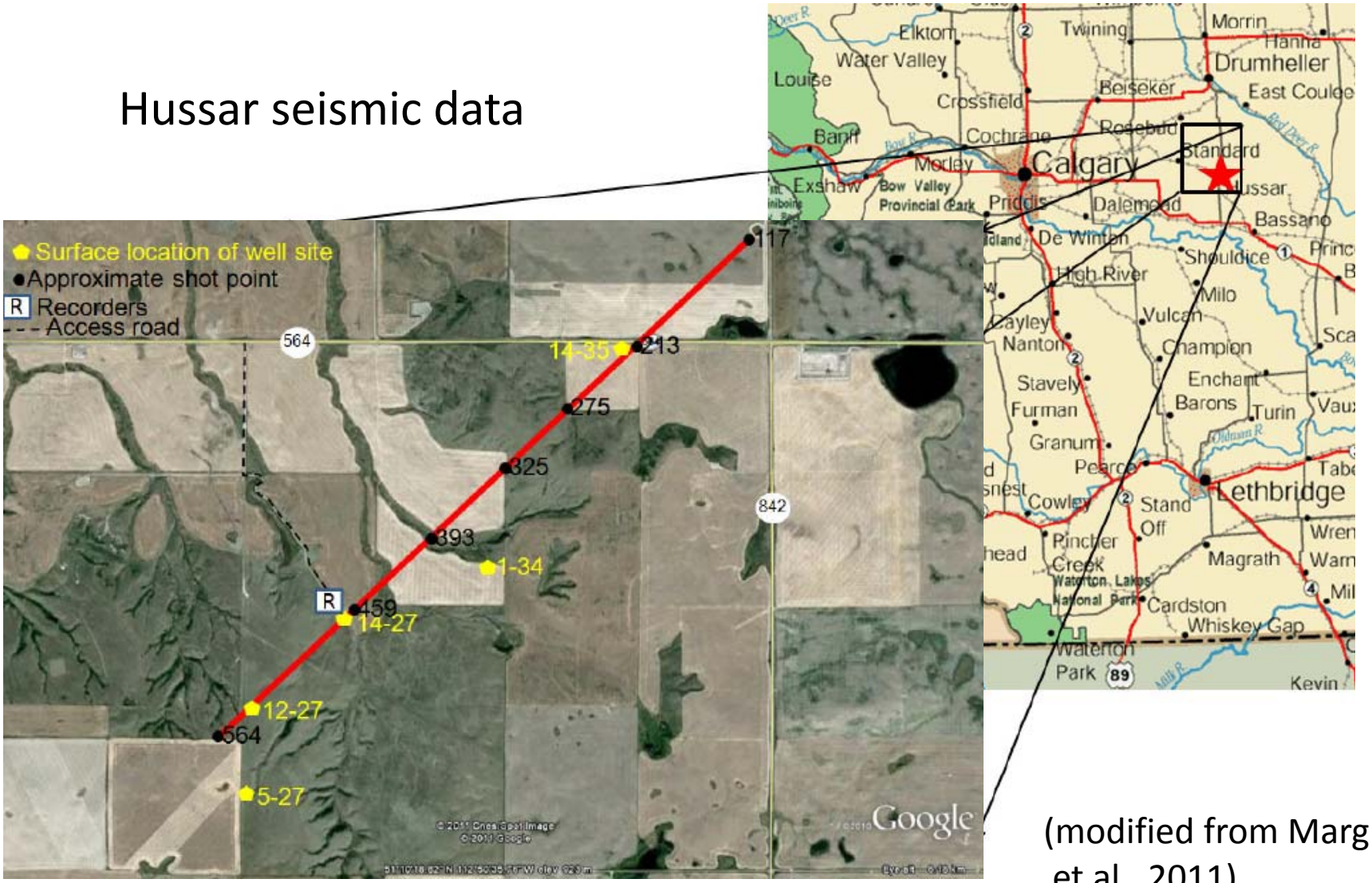
Objectives

- Perform a Vp/Vs analysis of the Hussar data.
- Suggest a minimum interval time for robust Vp/Vs analysis.
- Provide recommendations on horizons interpretation in order to reduce uncertainty in interval Vp/Vs
- Understand the sensitivity of Vp/Vs to interval time.

Area of Study

Hussar seismic data



(modified from Margrave et al., 2011)

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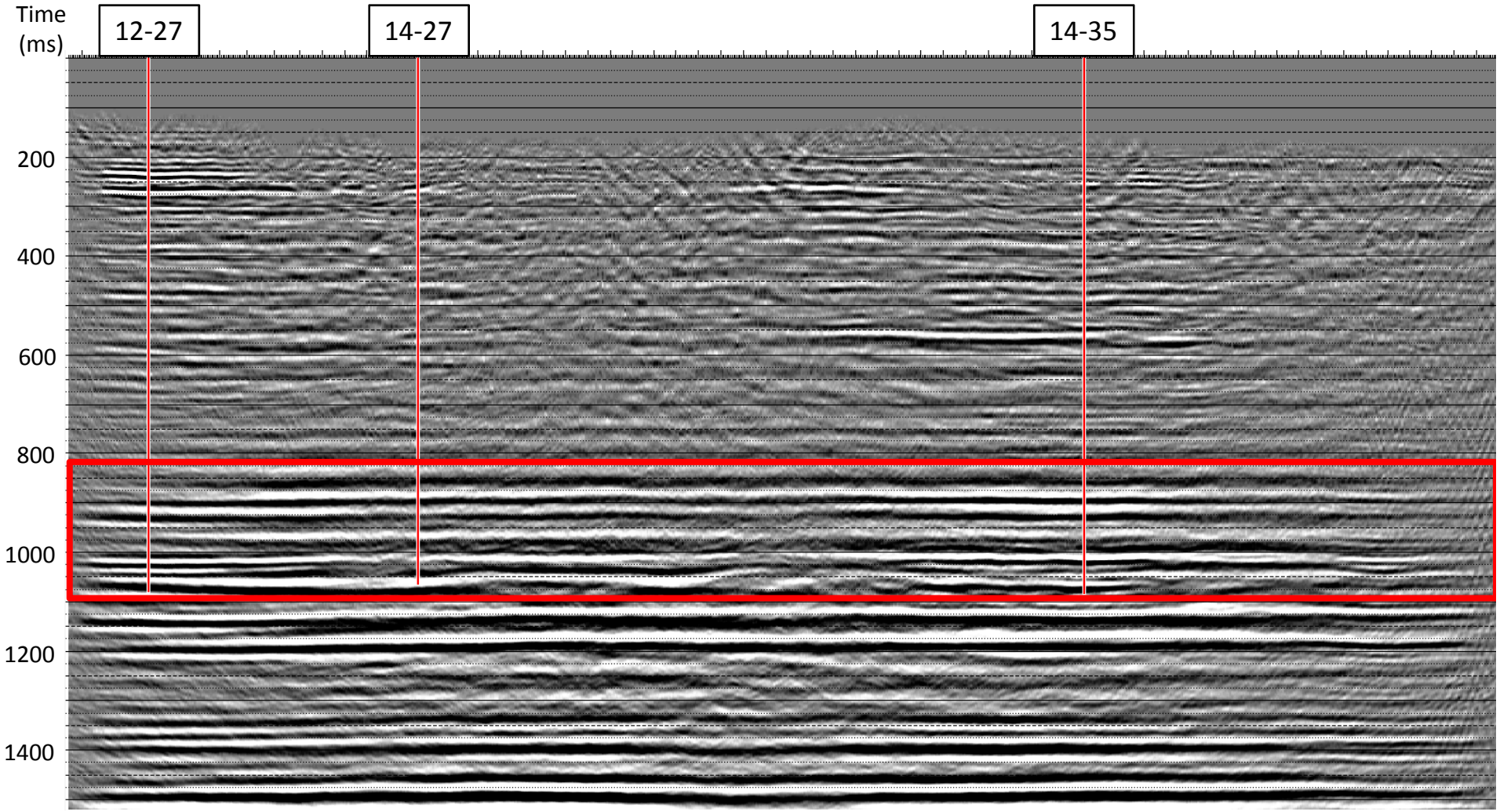
Input Data

PP Volume



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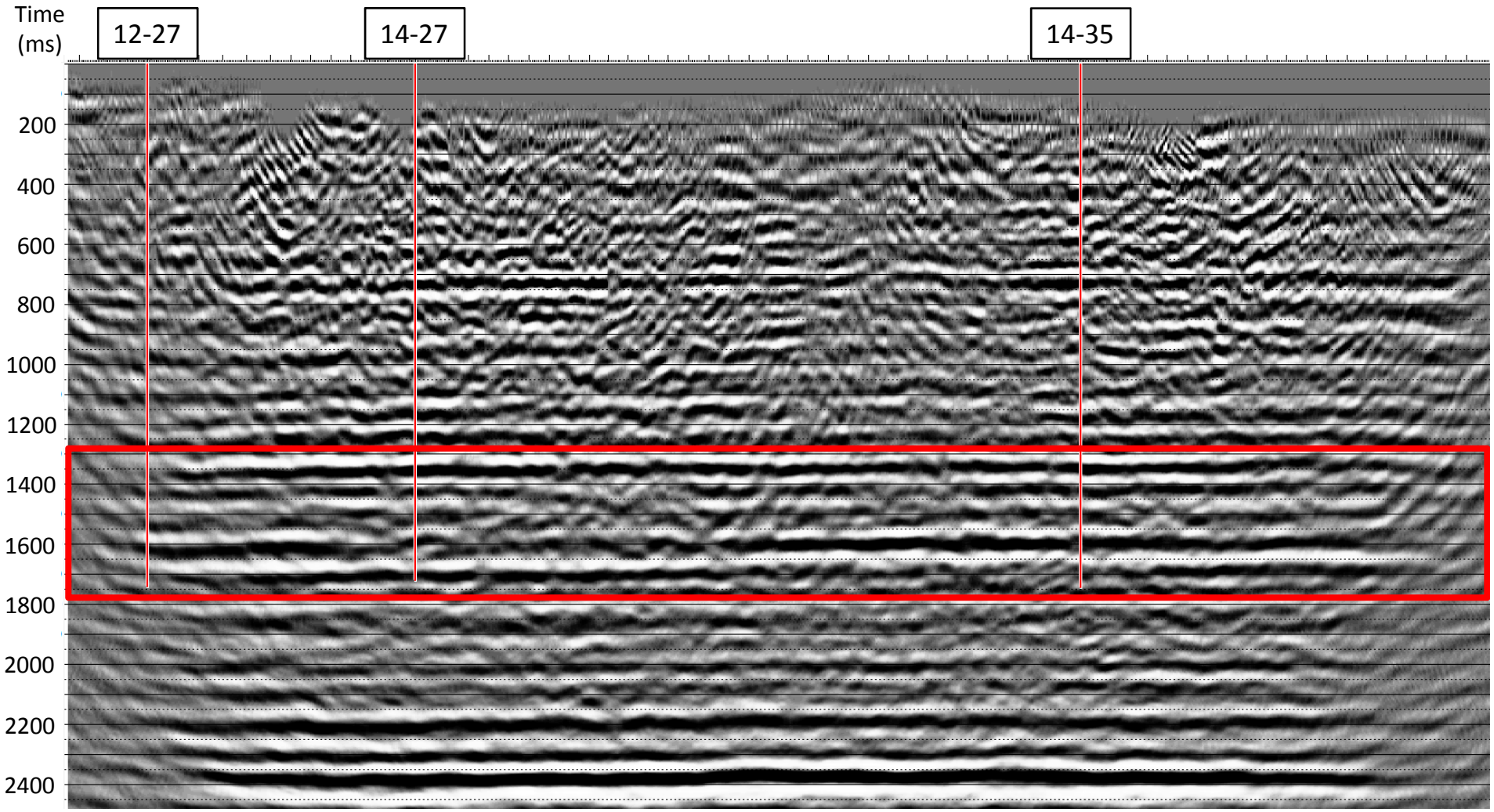
Input Data

PS Volume



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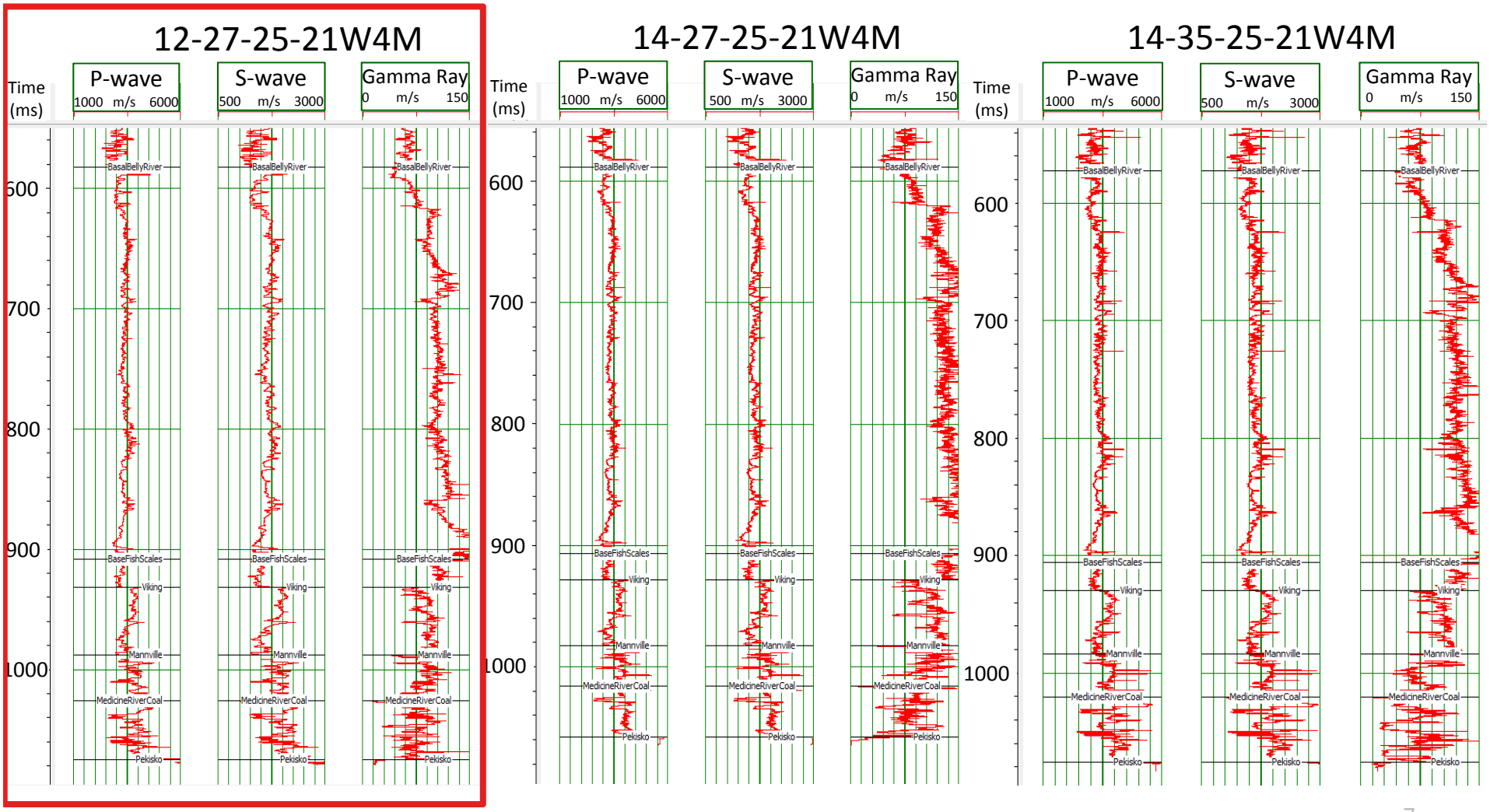
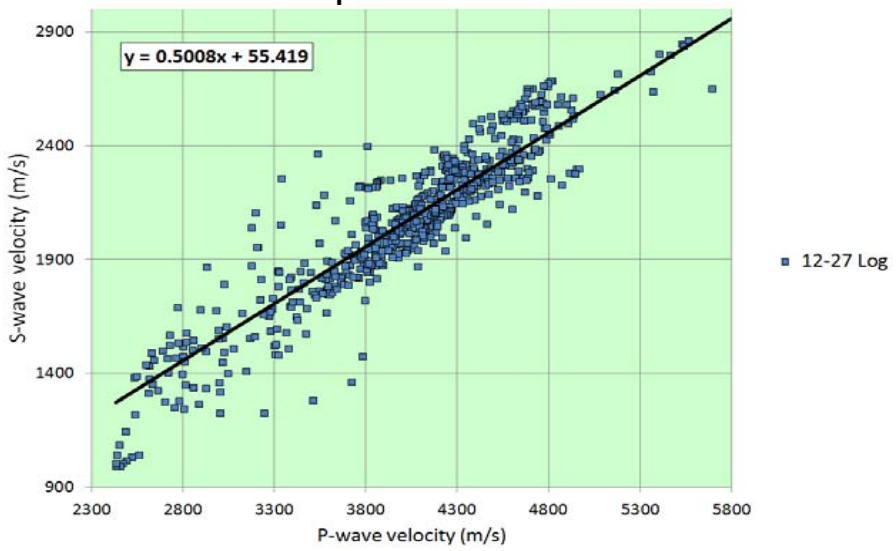
Input Data

Wells (Husky Energy)

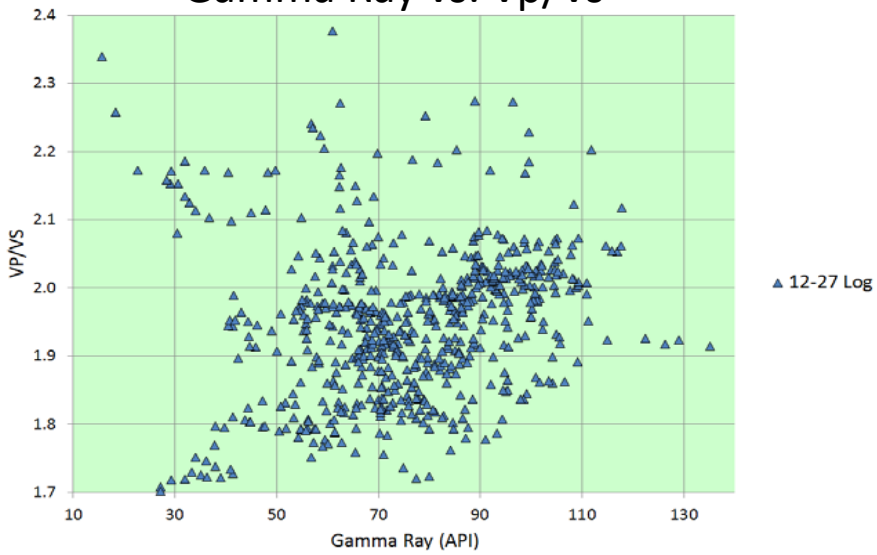


Input Data well 12-27

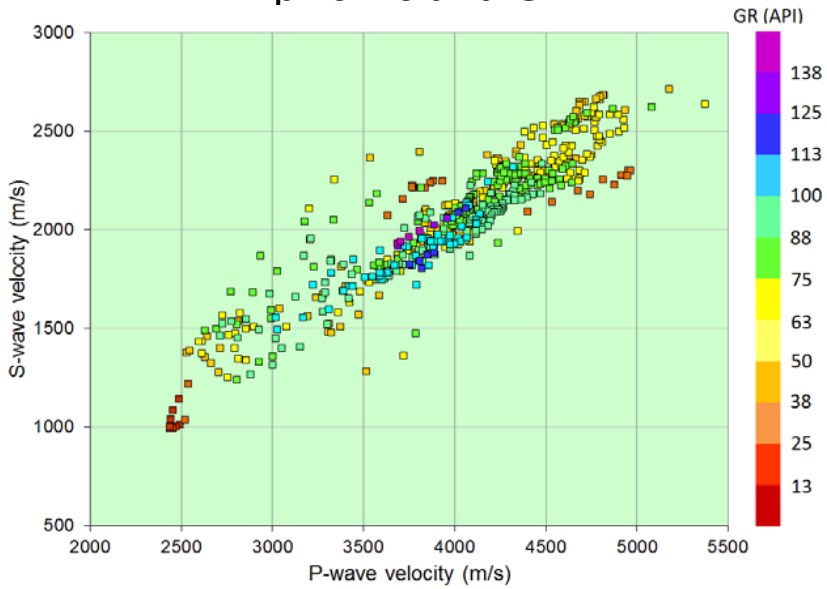
Vp vs. Vs



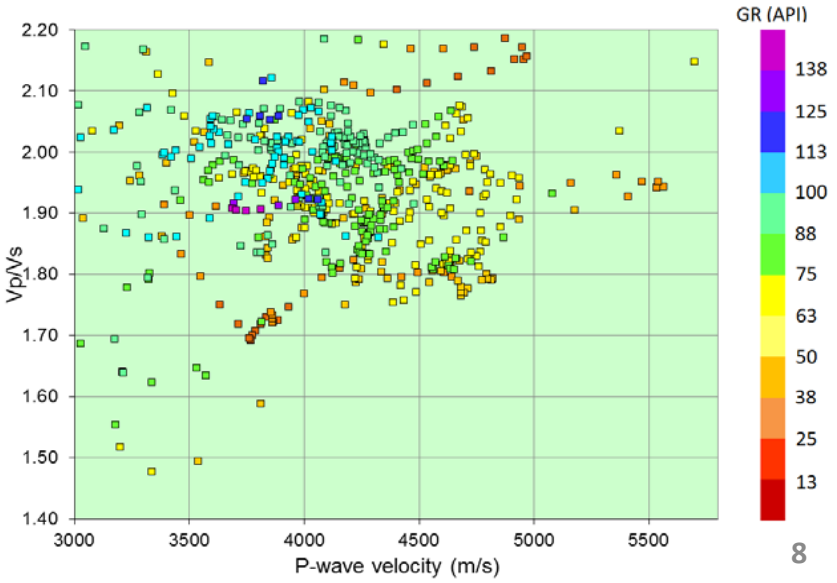
Gamma Ray vs. Vp/Vs



Vp vs. Vs and G.R.

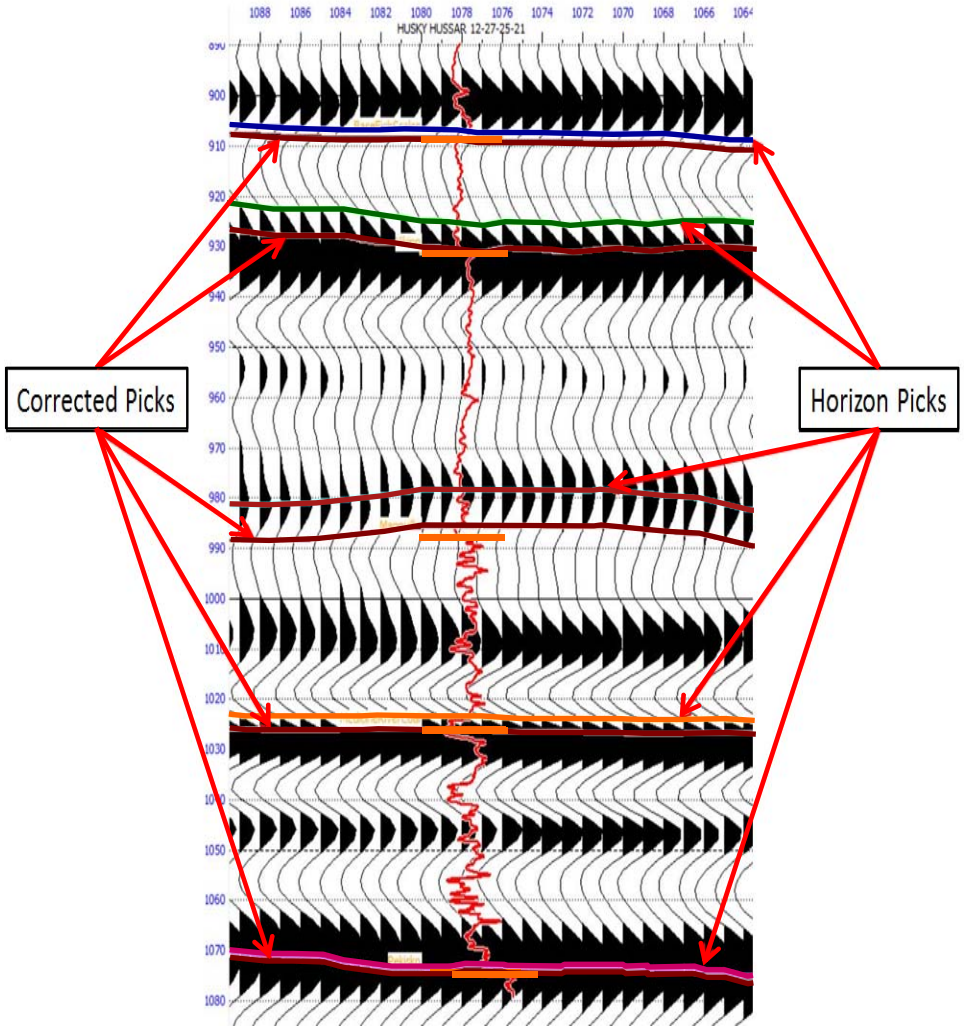


Vp/Vs vs. Vp and G.R.

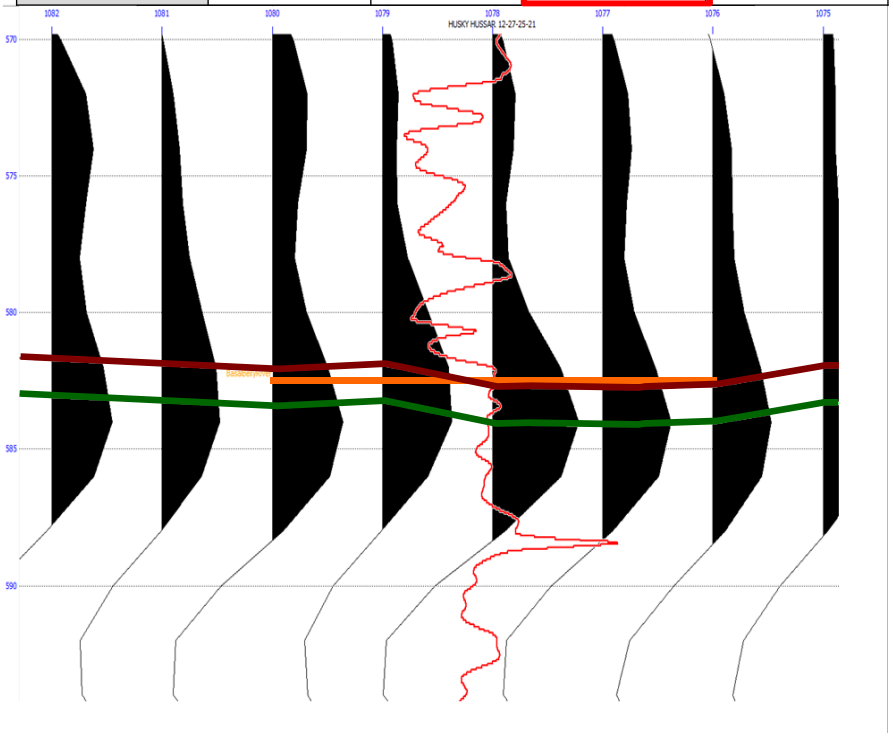


Hussar Data

Horizon Interpretation



	12-27 Log			All Logs
	Horizon Time	Top Time	Time Diff.	Average Corr.
BasalBellyRiver	584.02	582.51	-1.51	-1.35
BasalBellyRiver Corr.	582.67	582.51	-.16	--

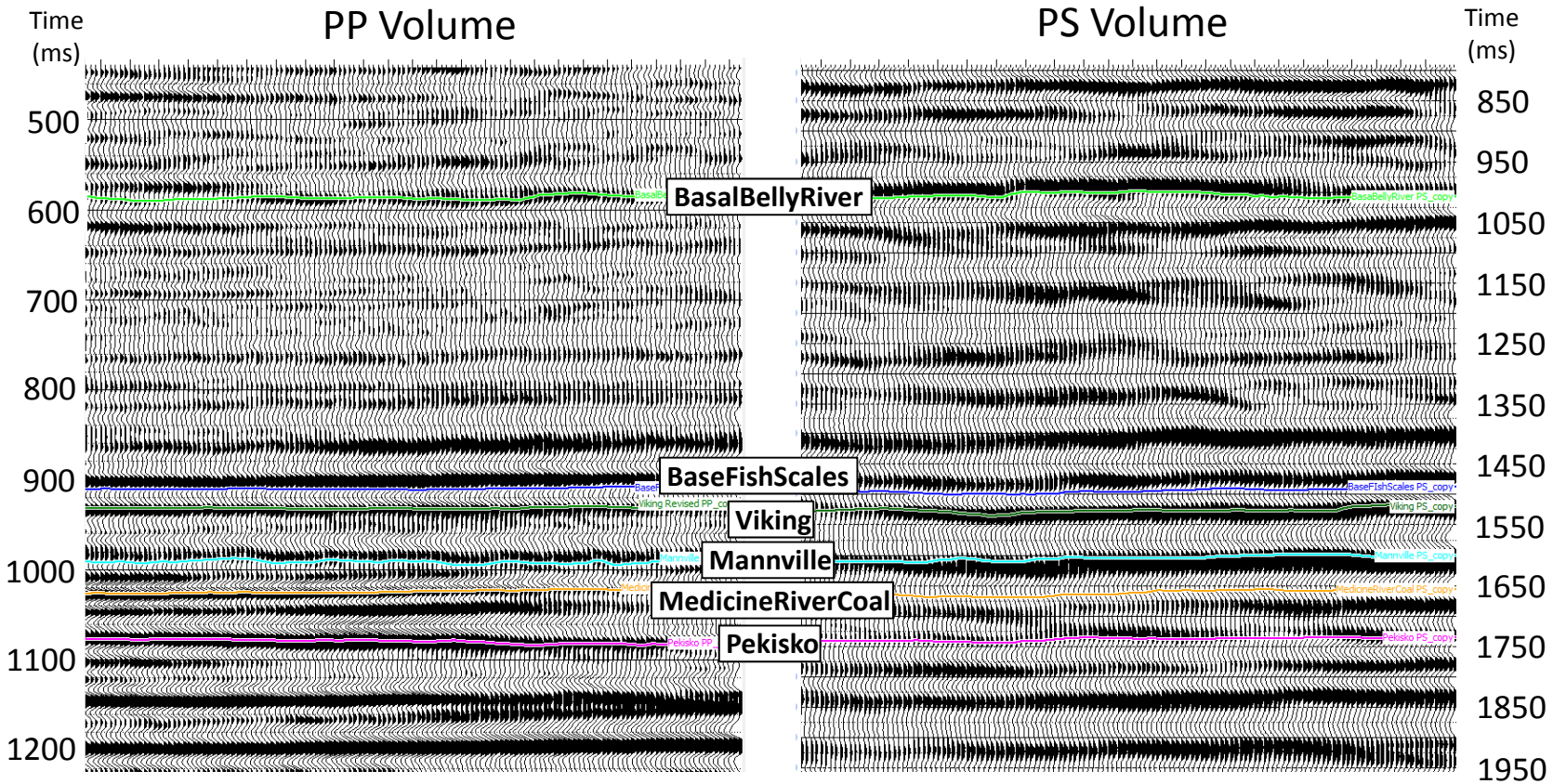


Hussar Data

Horizon Interpretation

Vp/Vs values were calculated using the following relationship (Garotta, 1987)

$$Vp/Vs = \frac{(2\Delta Tps - \Delta Tpp)}{\Delta Tpp}$$

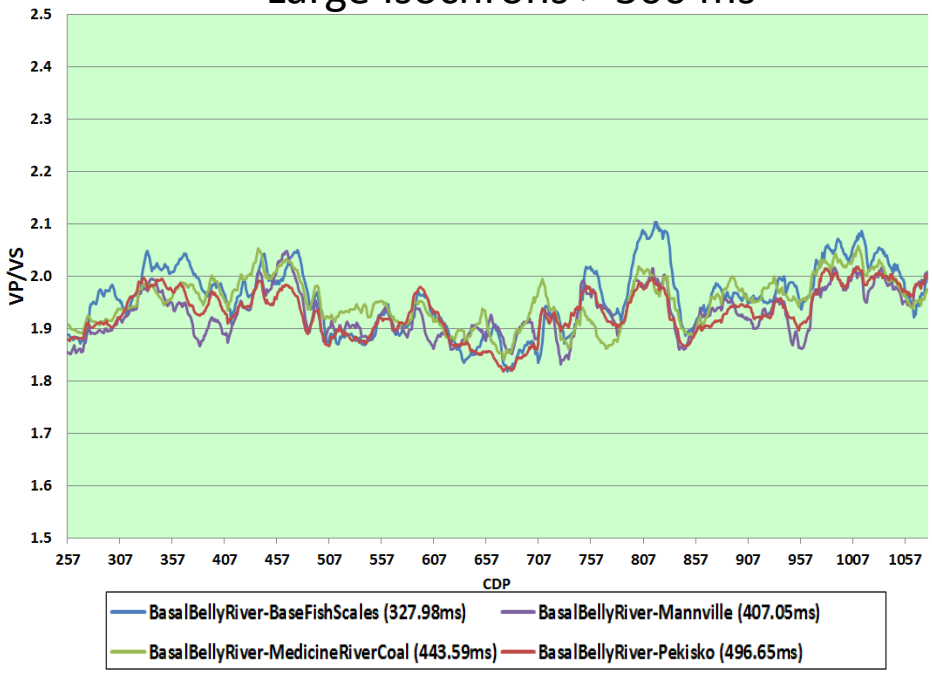


Hussar Data

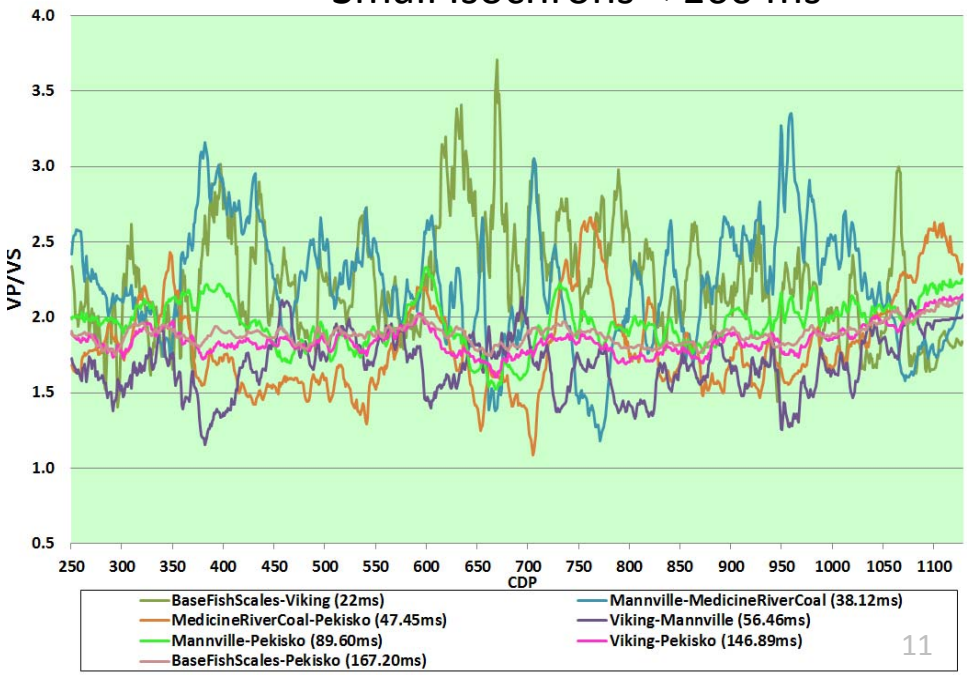
	PP Time Interval ΔT (ms)
	Average
BasalBellyRiver-BaseFishScales	327.98
BaseFishScales-Viking	22.55
Viking-Manville	56.46
Mannville-MedicineRiverCoal	38.12
MedicineRiverCoal-Pekisko	47.45
BasalBellyRiver-Pekisko	496.65
BasalBellyRiver-MedicineRiverCoal	443.59
BasalBellyRiver-Mannville	407.05
BaseFishScales-Pekisko	167.20
Mannville-Pekisko	89.60
Viking- Pekisko	146.89

- Total of 6 Horizons Interpreted.
- 11 Isochrons range from approximately 22 ms to 500 ms.

Large Isochrons > 300 ms



Small Isochrons < 160 ms



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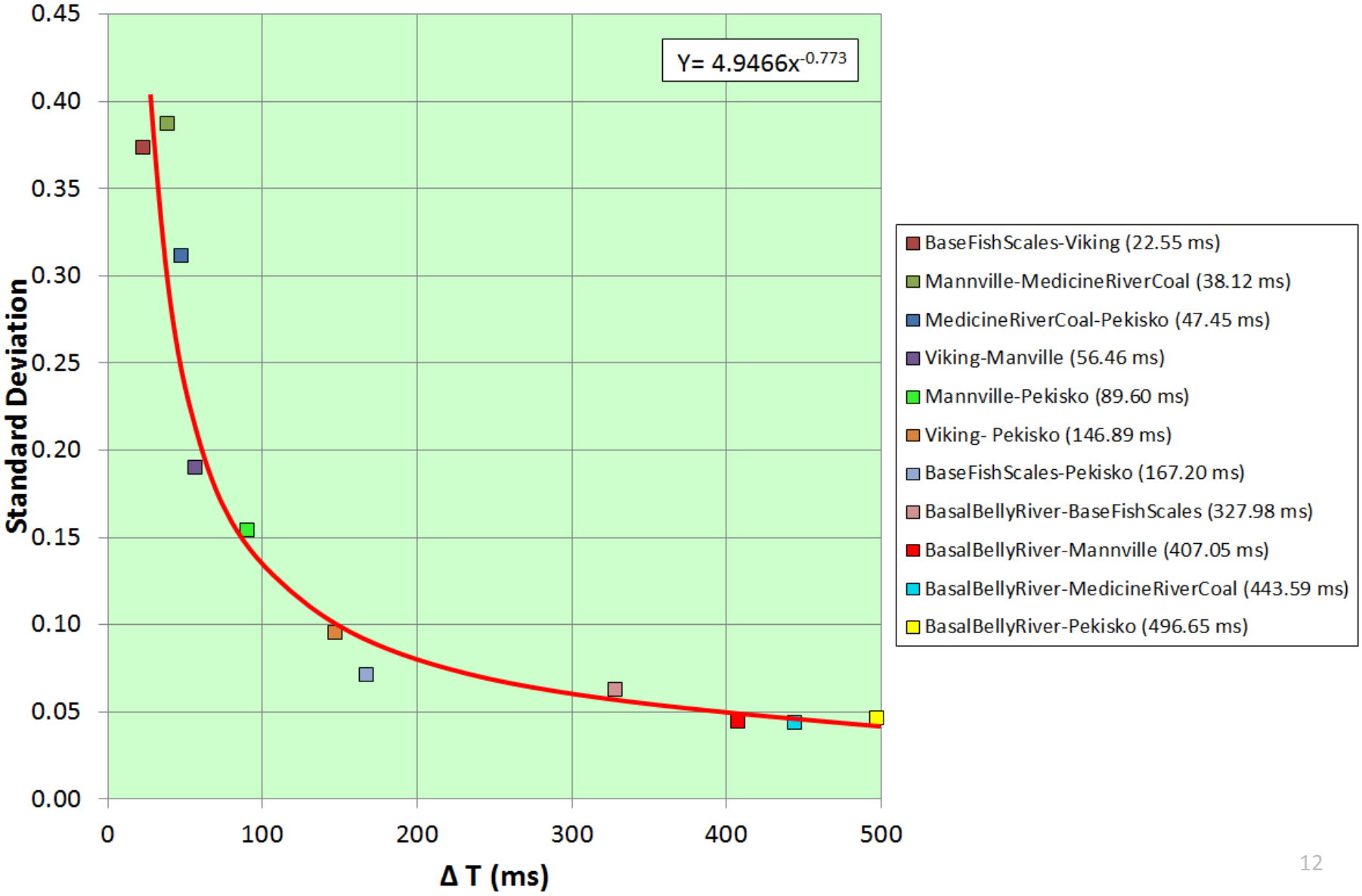
Sensitivity Analysis



Sensitivity Analysis

First step:

Examine the equation

$$\text{(y)}\quad \frac{Vp}{Vs} = \frac{(2\Delta Tps - \Delta Tpp)}{\Delta Tpp} = \frac{2\Delta Tps}{\Delta Tpp} - 1$$

(x)

(z)

Assumptions: ±2ms uncertainty in the horizons interpretation

Sensitivity Analysis

First step:

Examine the equation

$$\text{(y)}\quad \frac{Vp}{Vs} = \frac{(2\Delta Tps - \Delta Tpp)}{\Delta Tpp} = \frac{2\Delta Tps}{\Delta Tpp} - 1$$

(x) (z)

Assumptions: ±2ms uncertainty in the horizons interpretation

Second step:

Evaluate the propagation of error equation

$$u(y) = \sqrt{{c_1}^2 u(x_1)^2 + {c_2}^2 u(x_2)^2 + \cdots {c_n}^2 u(x_n)^2} \quad \text{(Louro, 2014)}$$

Sensitivity Coefficient $\rightarrow c_i = \frac{\partial y}{\partial x_i}$

$$^{vp}/_{vs}\,(error) = \sqrt{\frac{4}{z^2}u(x)^2 + \frac{4x^2}{z^4}u(z)^2;} = 4\sqrt{\frac{1}{\Delta Tpp^2} + \frac{\Delta Tps^2}{\Delta Tpp^4}}$$

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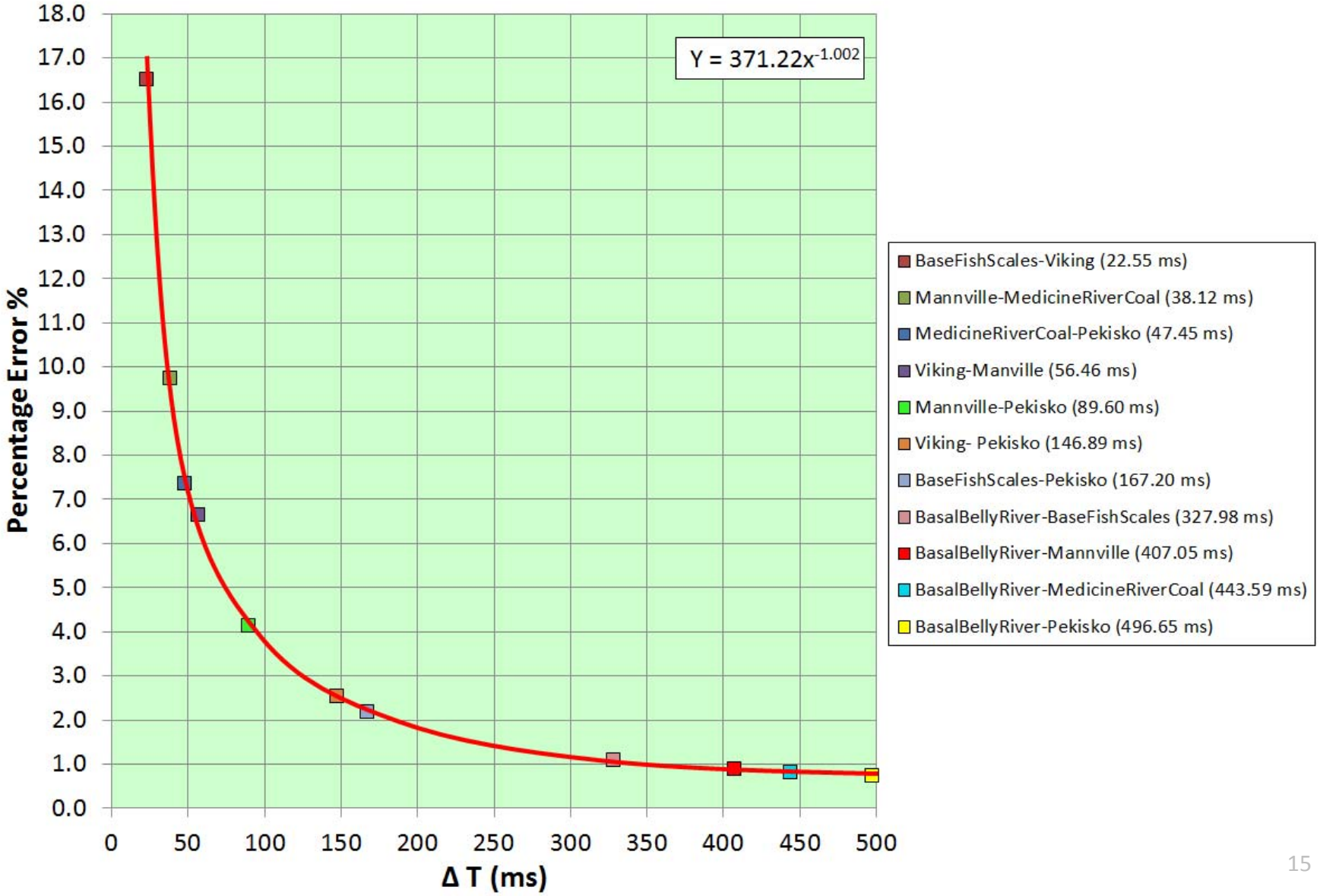
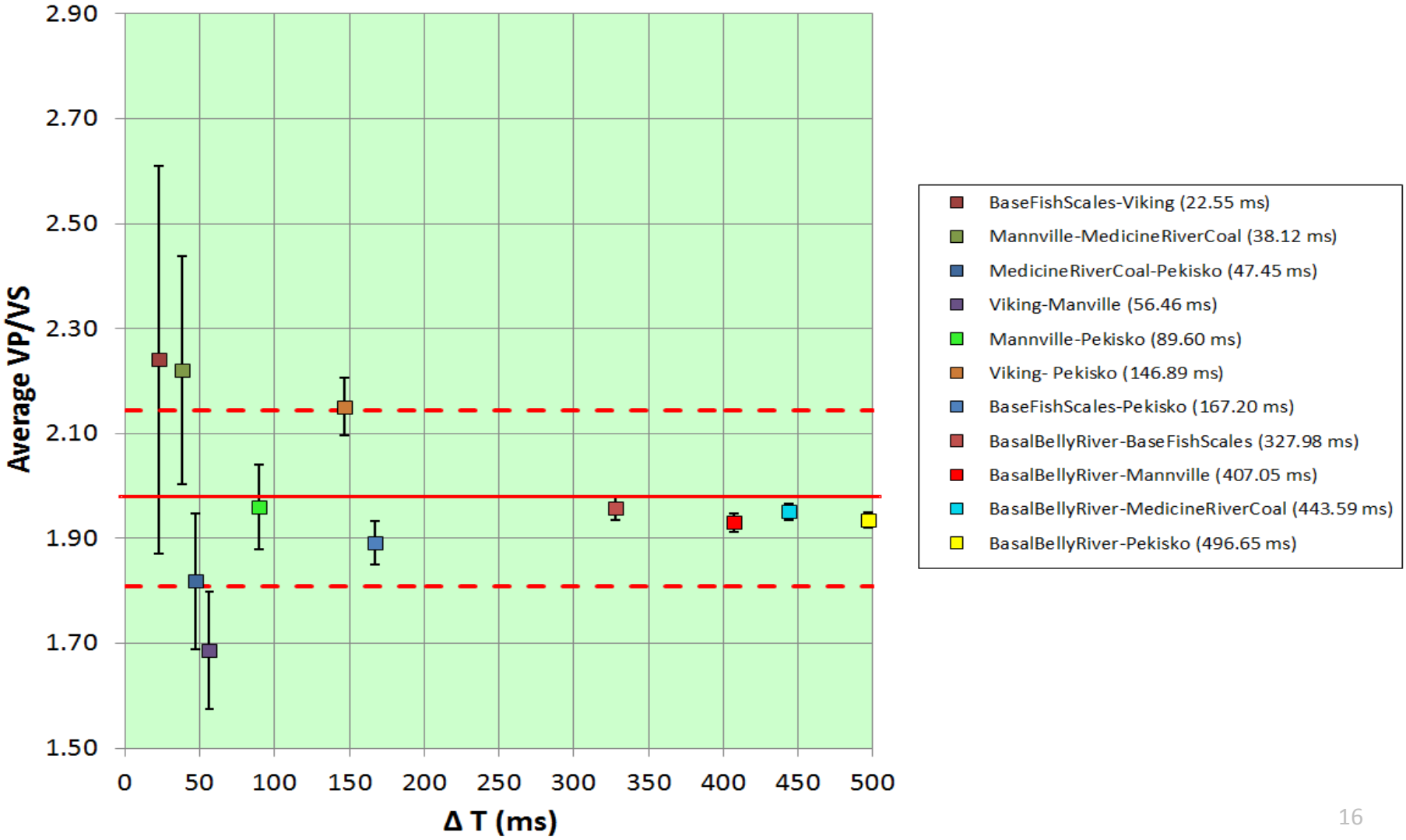
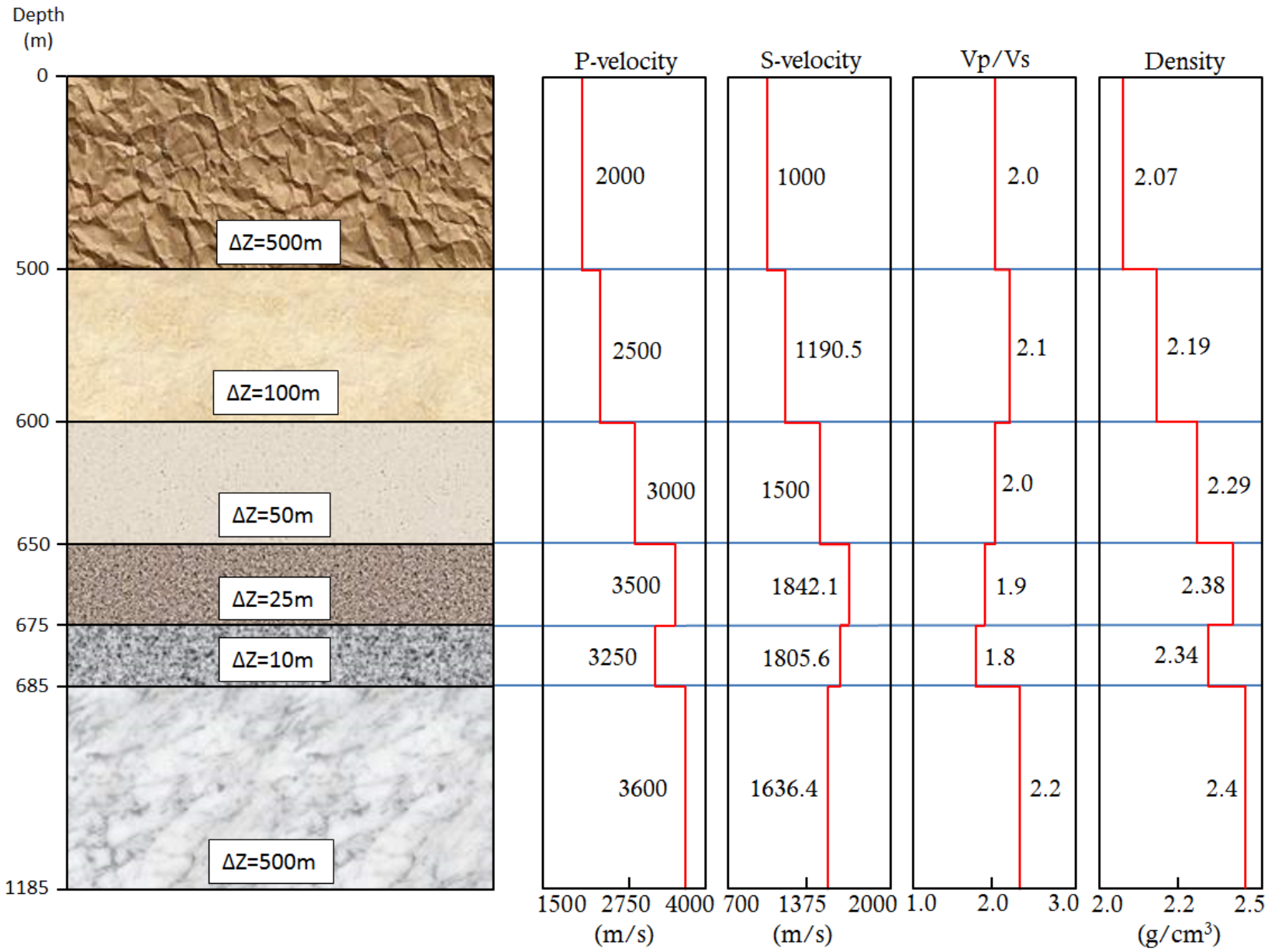
Sensitivity Analysis



Sensitivity Analysis

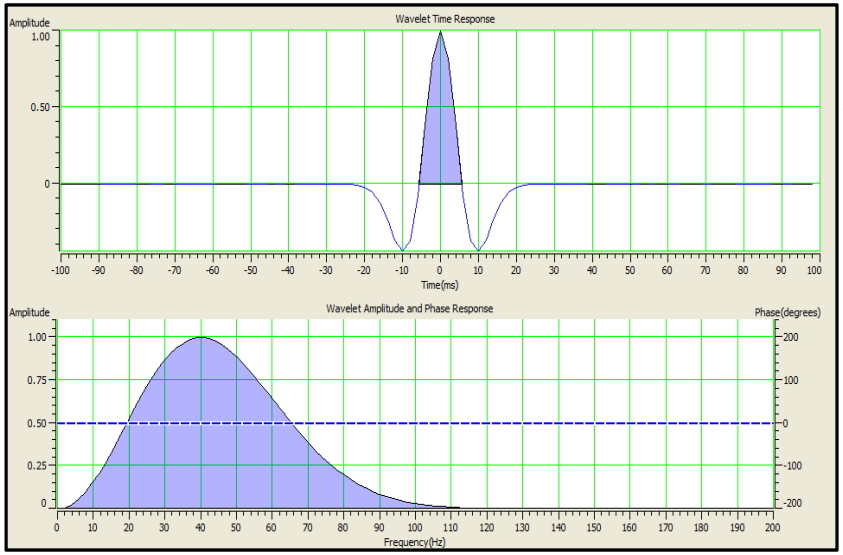


Synthetic Model

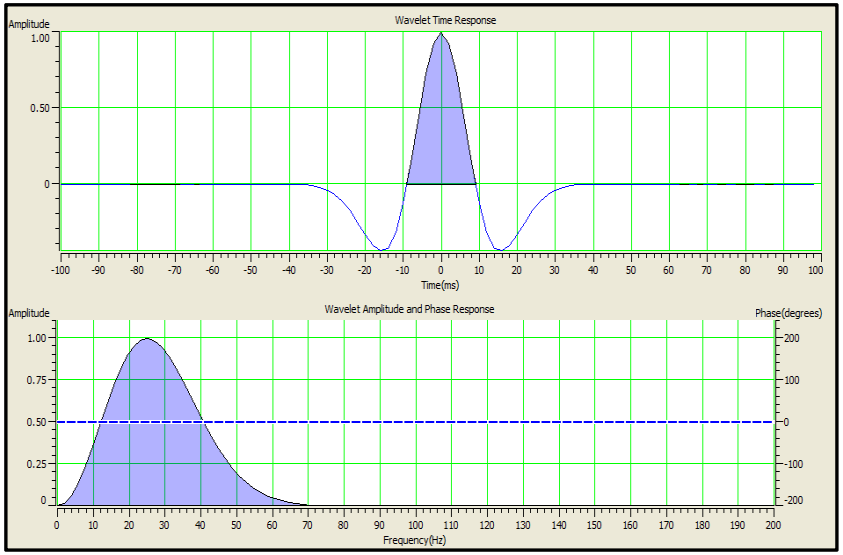


Synthetic Model

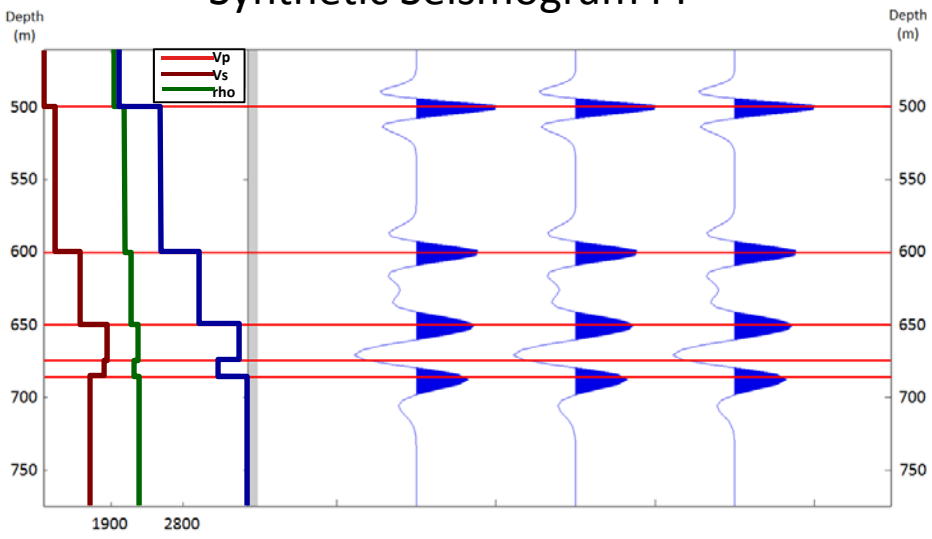
PP Wavelet



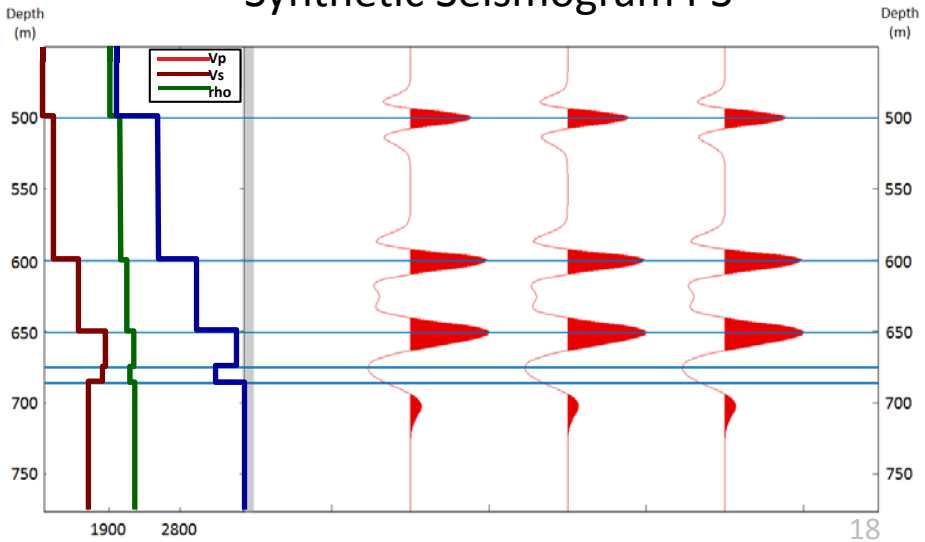
PS Wavelet



Synthetic Seismogram PP

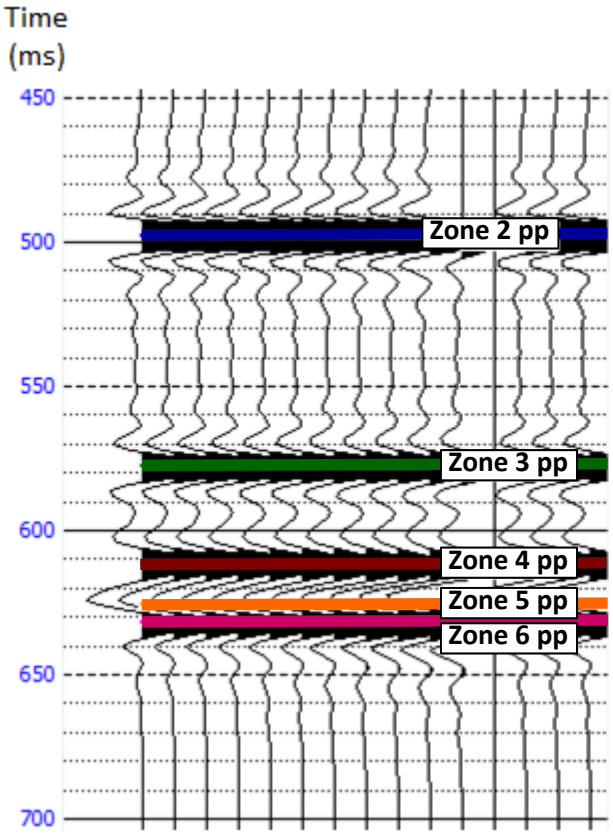


Synthetic Seismogram PS

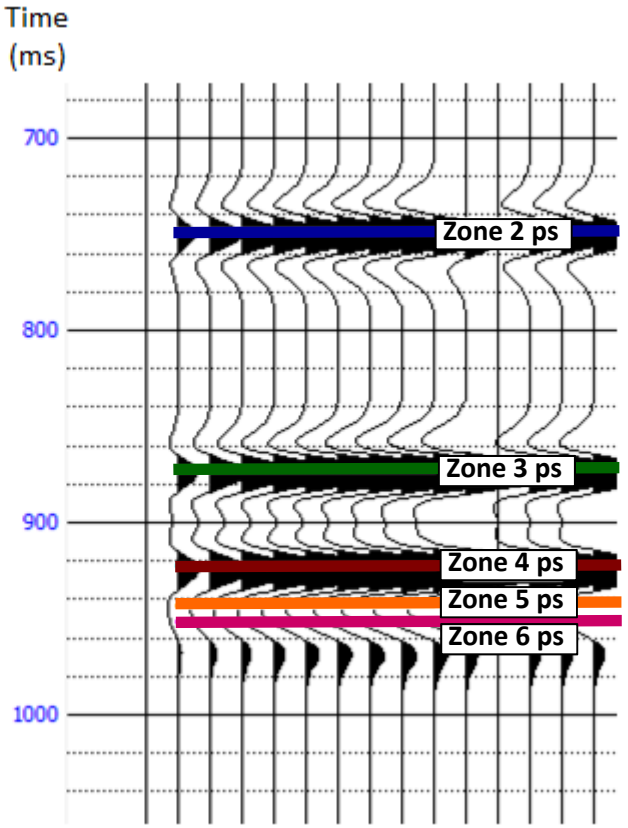


Synthetic Model

PP Seismic

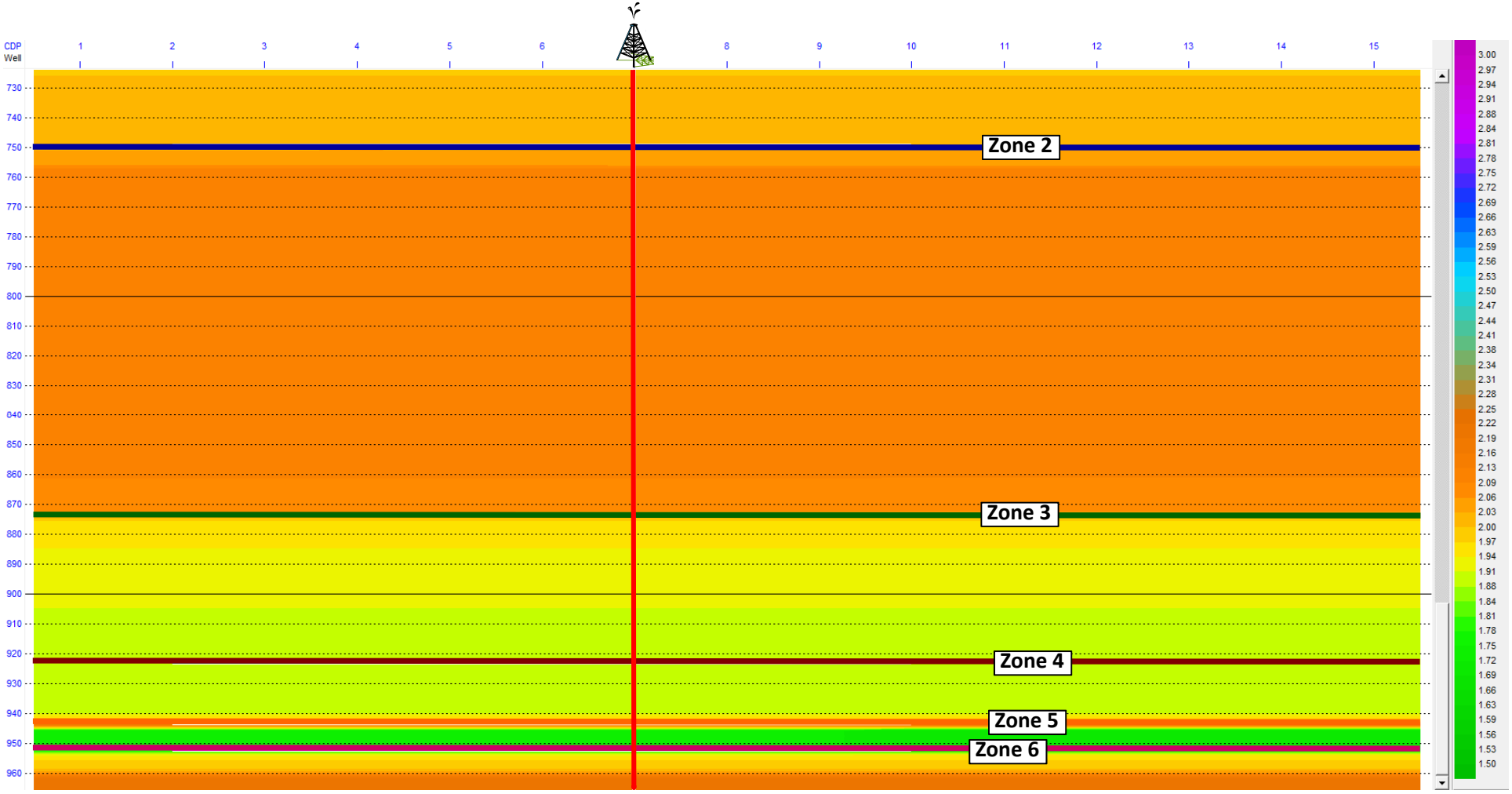


PS Seismic



Synthetic Model

Vp/Vs analysis



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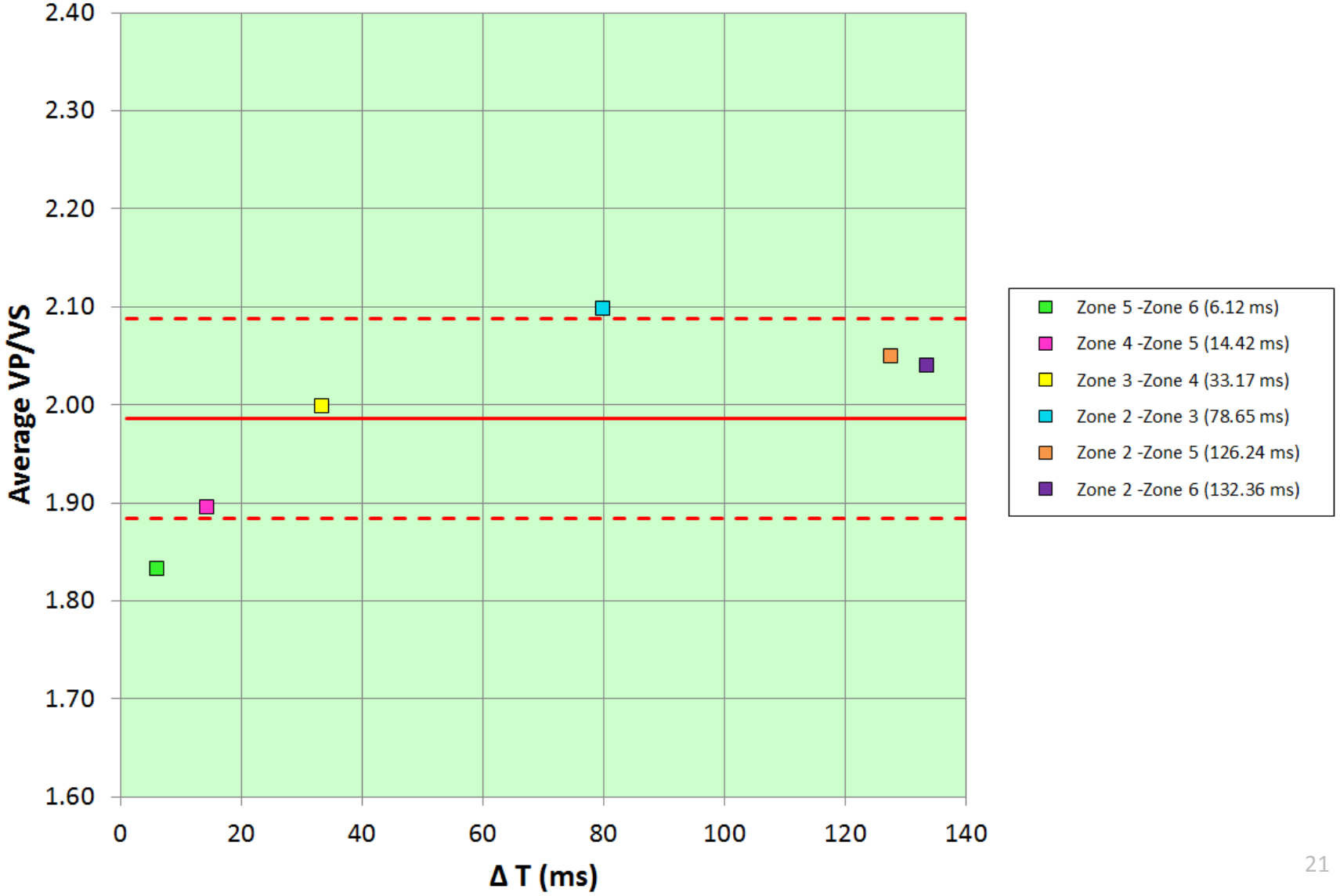
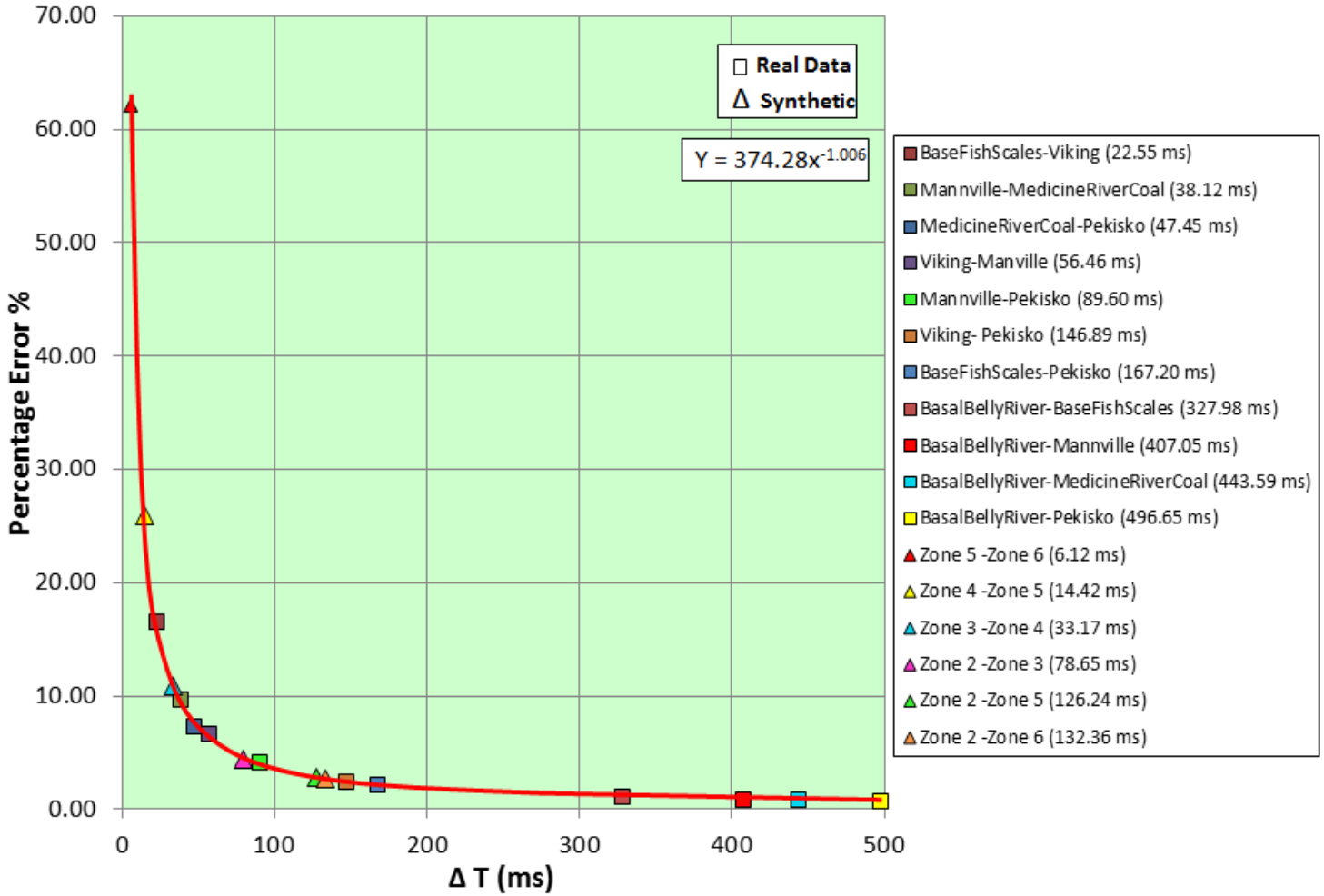


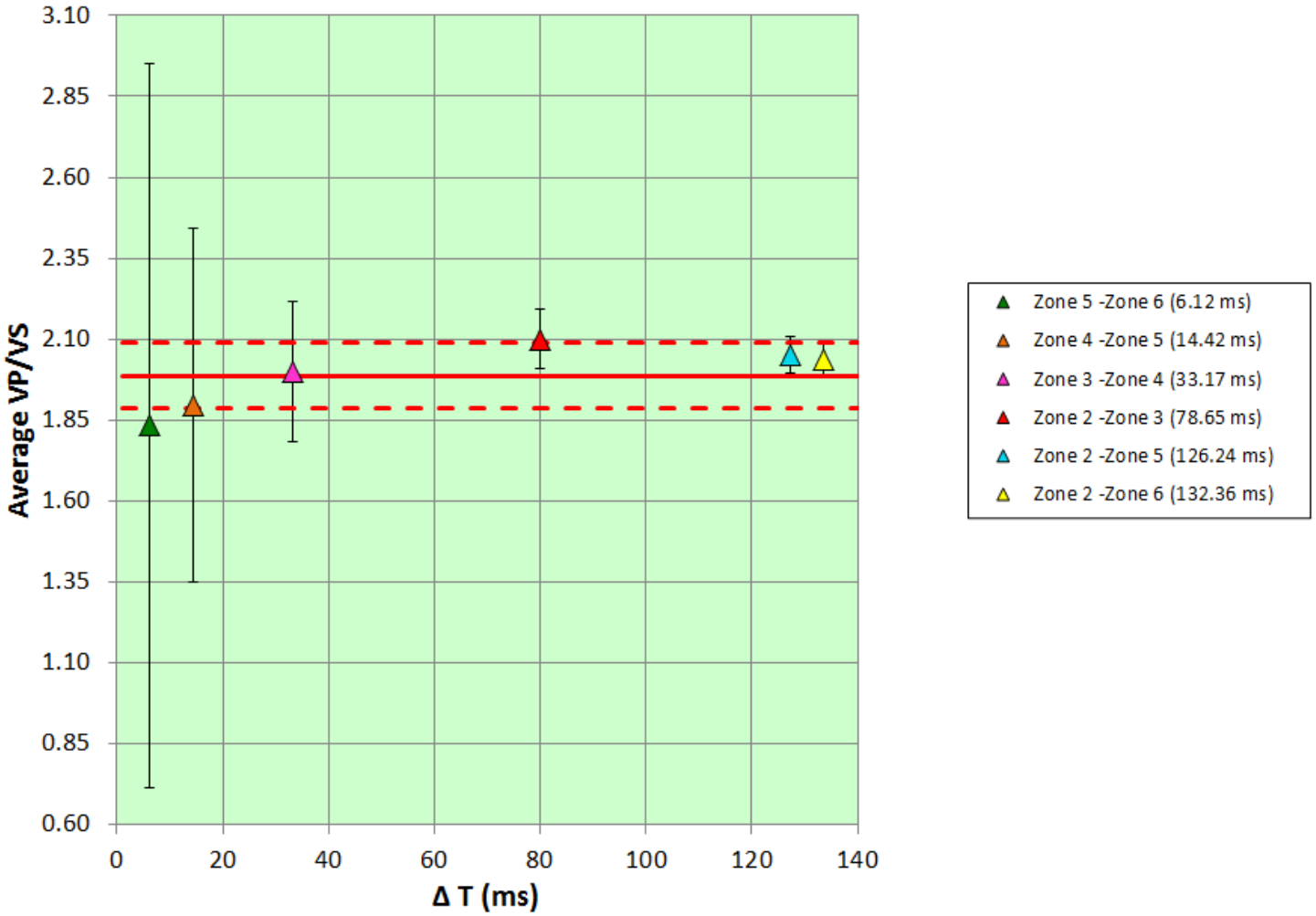
Synthetic Model

Vp/Vs analysis assuming ± 2ms uncertainty



Synthetic Model

Vp/Vs analysis assuming ± 2ms uncertainty



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Conclusions

- Analysis performed on the Hussar data indicates that the uncertainty in Vp/Vs values will increase as time interval becomes smaller.
- Based on the increasing behavior of error with respect to decrease in the time interval, it is suggested to use isochron intervals greater than 150 ms.
- Precise Horizon interpretation helps reduce uncertainty for Vp/Vs calculations.
- Results shows standard deviation to be affected by the interval time chosen.
- Vp/Vs values in large isochrons are affected mostly by heterogeneity in the geology.

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