P-wave and S-wave near-surface characterization in NEBC

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CREWES

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Outline

- Objective
- Theory and procedure
- Velocity and depth analysis
  - SH data analysis / P-wave data analysis
- Receiver static corrections
- Vp/Vs analysis
- Field data & PP - PS registration
- Conclusions

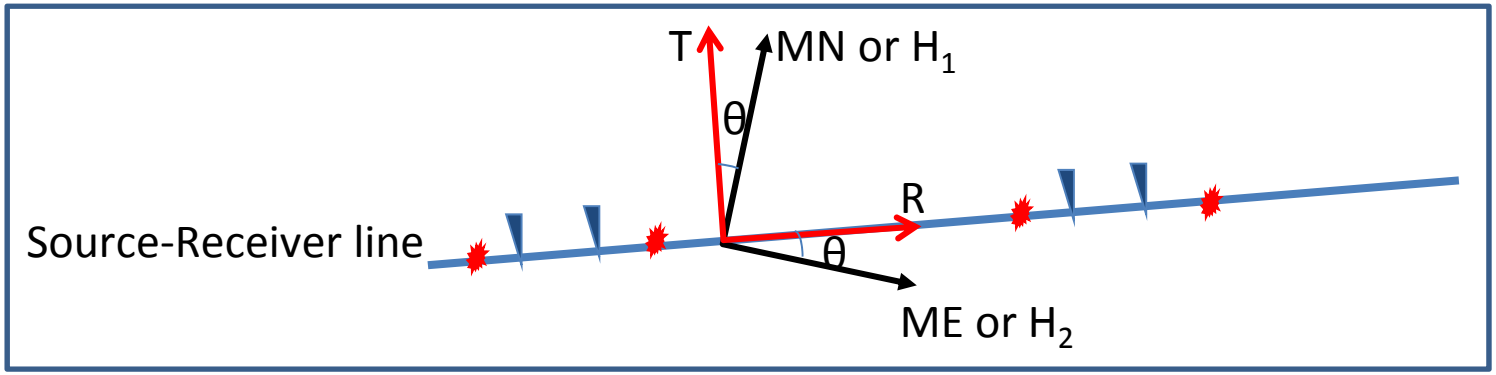
Objectives

- Obtain precise P-wave and S-wave depth-velocity models for the near-surface.
- Compare Vp/Vs results with well log data.
- Derive S-wave statics as these are known to be much greater than P-wave statics and are difficult to obtain.
- Ultimately apply results of this work to the processing of a 3D/3C seismic survey that will be acquired in the same area, and to provide constraints on registration of PP and PS volumes.

Procedure

- Two datasets: Vibrator sources in V and SH mode. Multi-component receivers.
- Rotate the horizontal component data, pick first break arrivals, apply the plus-minus analysis method and determine near-surface velocity and depth model.
- Calculate static corrections to datum for P and S data.
- Register PP and PS data for shallow horizons

Data Rotation

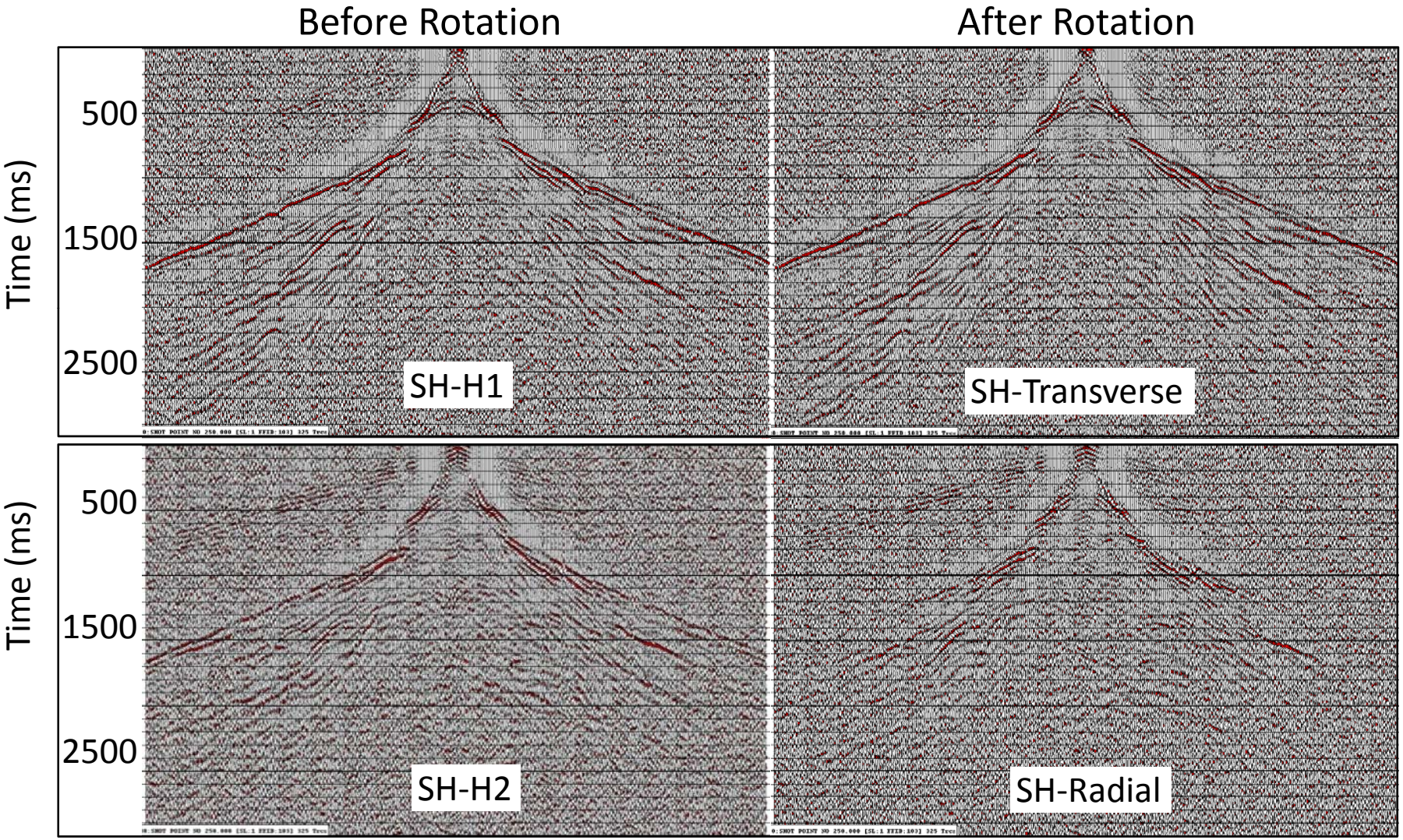


$$R = H_2 * \cos\theta + H_1 * \sin\theta$$

$$T = H_1 * \cos\theta - H_2 * \sin\theta$$

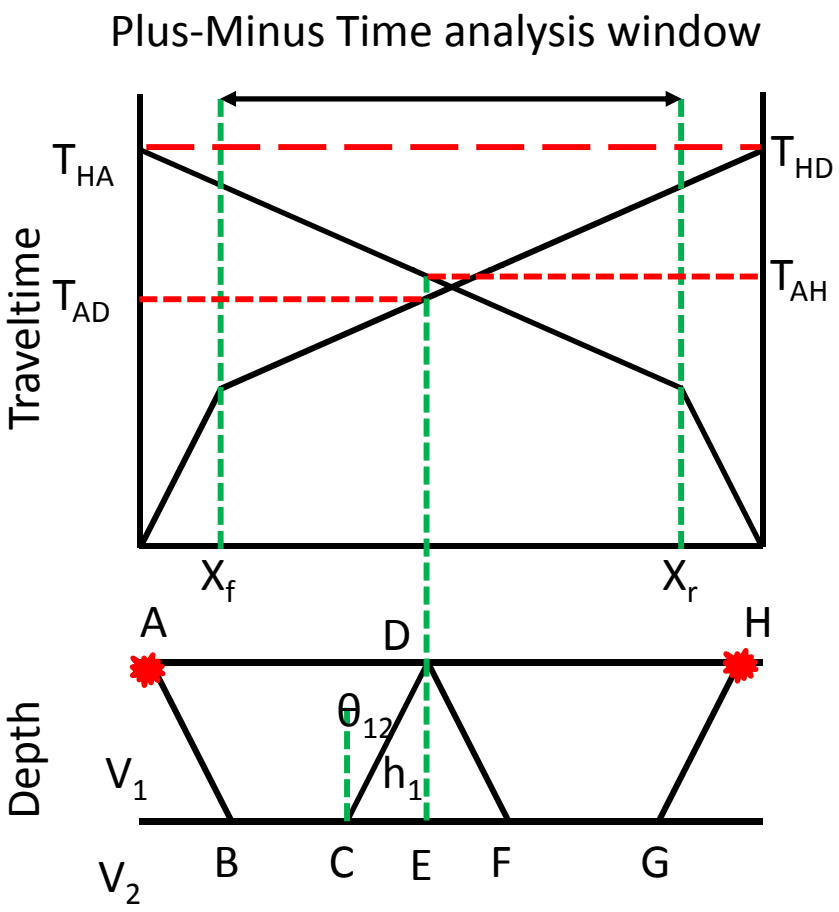
- Shear wave data processing requires the rotation of the data acquired.
- The radial component (R) contains predominantly SV and P-wave modes, while the transverse (T) data are predominantly SH.

Field data and rotations



Maximum offset = 1500 m

Plus-minus analysis



$$T_D^+ = T_{AD} + T_{HD} - T_{AH}$$

2-layer case

$$h_1 = \frac{T_D{}^+ * V_1}{2\cos\theta_{12}}$$

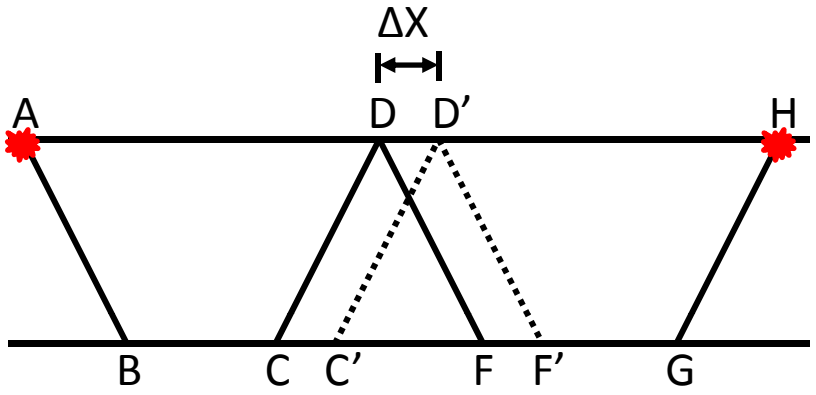
3-layer case

$$h_2 = \left[T_D{}^+ - \frac{2 * h_1 * \cos\theta_{13}}{V_1} \right] * \frac{V_2}{2\cos\theta_{23}}$$

Where

$$\theta_{ij} = \sin^{-1}(V_i / V_j)$$

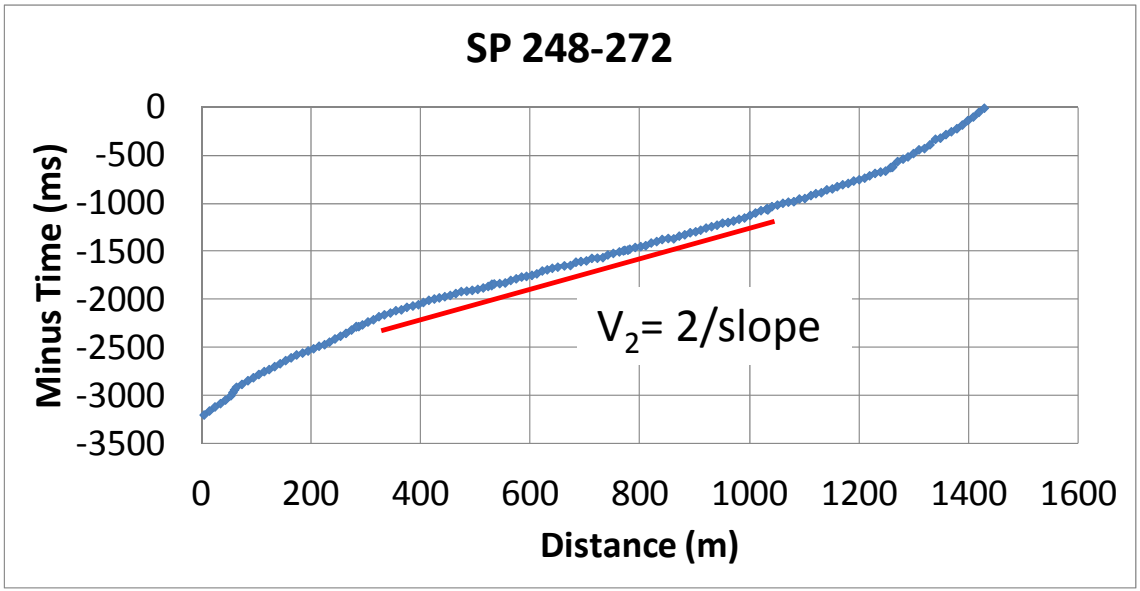
Velocity analysis



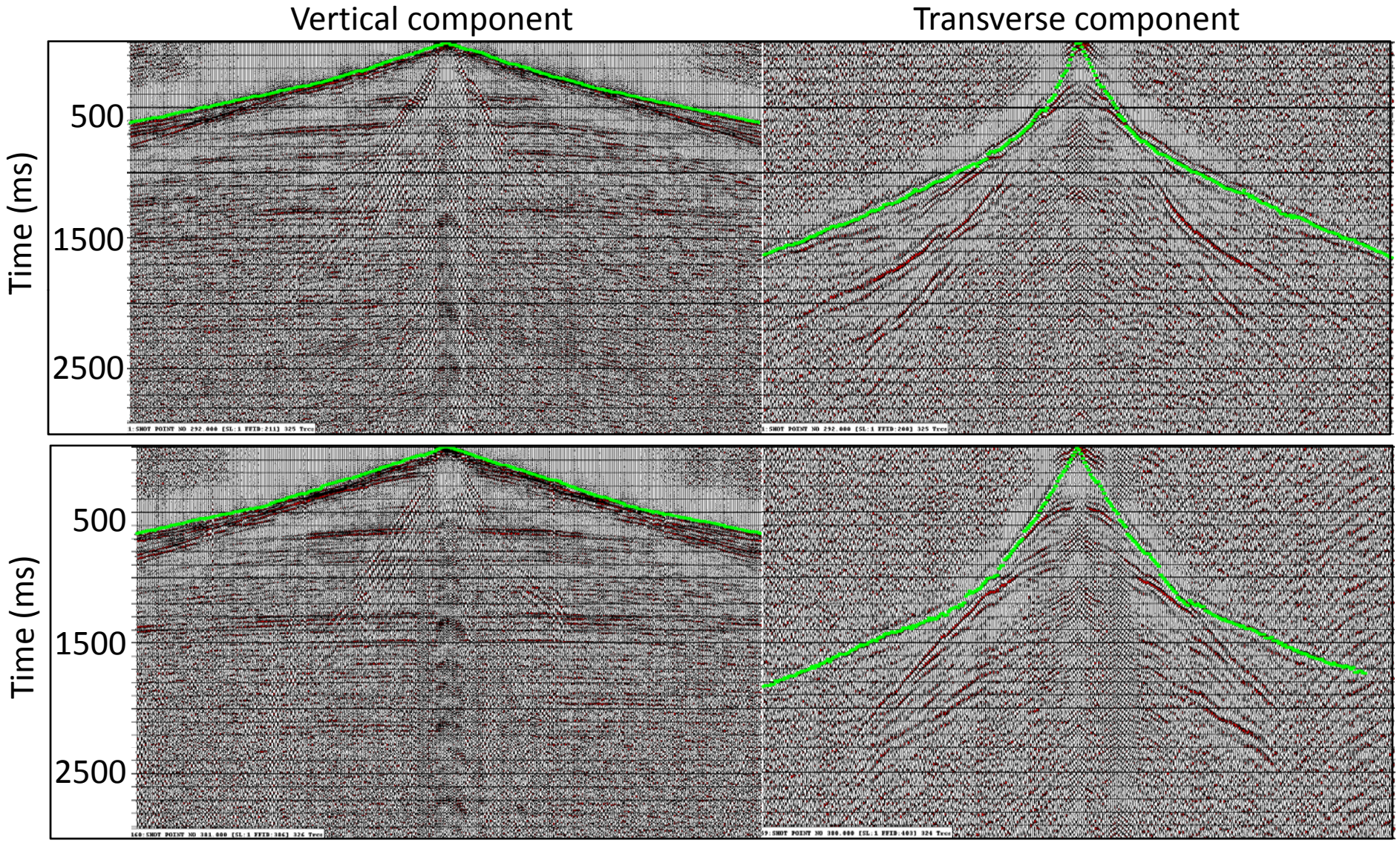
$$T_D^- = T_{AD} - T_{HD} - T_{AH}$$

$$T_{D'}^- = T_{AD'} - T_{HD'} - T_{AH}$$

$$T_D^- = T_{D'}^- - \frac{2 * \Delta X}{V_2}$$

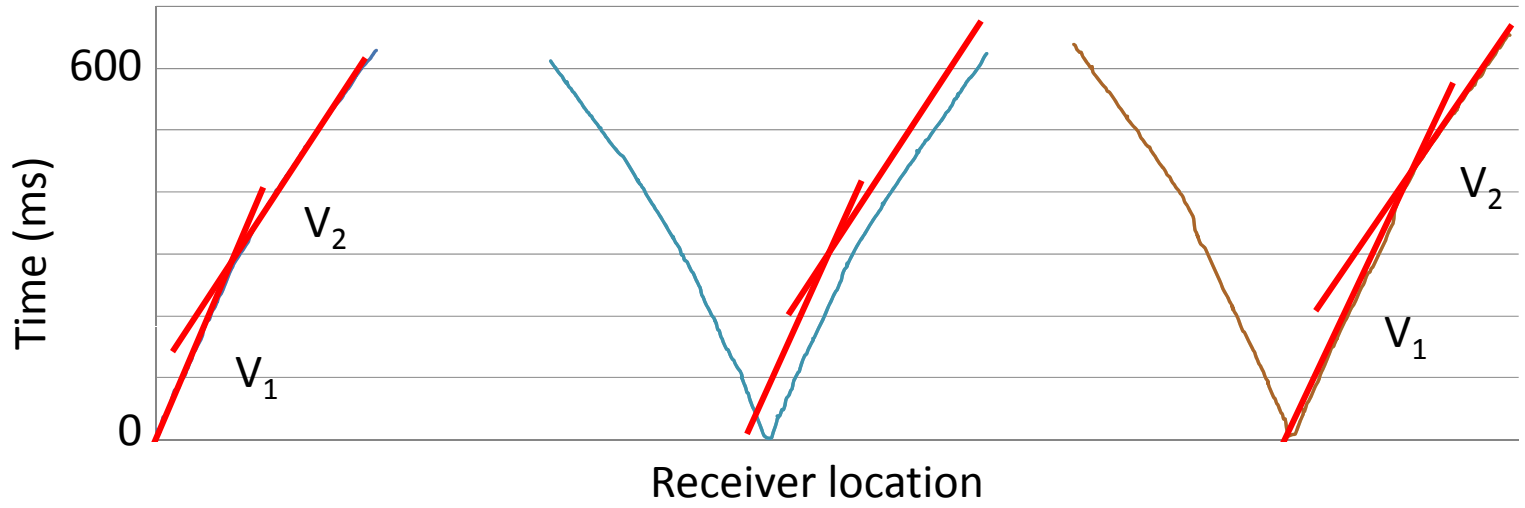


Data & first-break picks

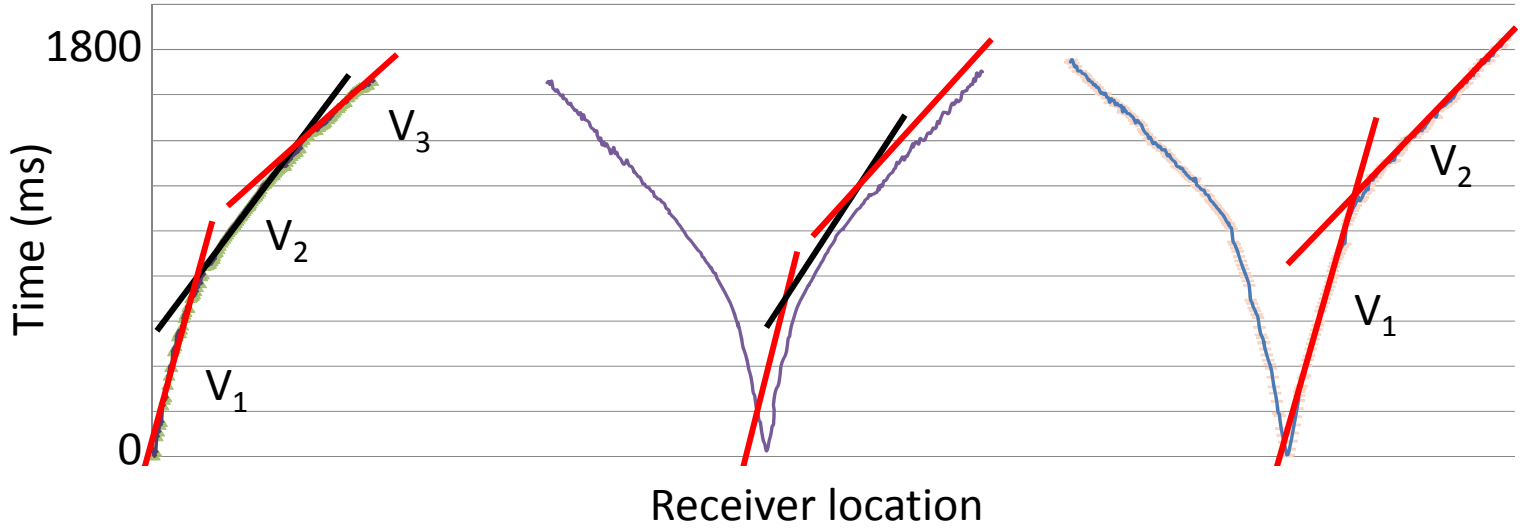


First-break travel-time analysis

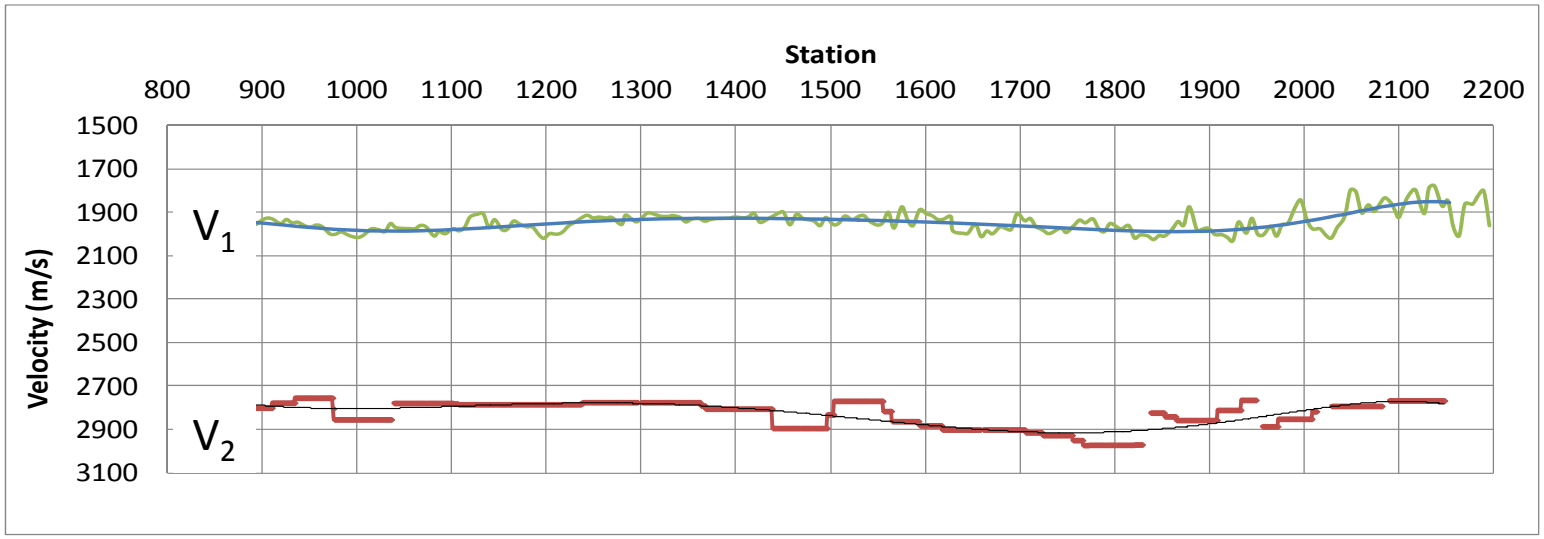
P data

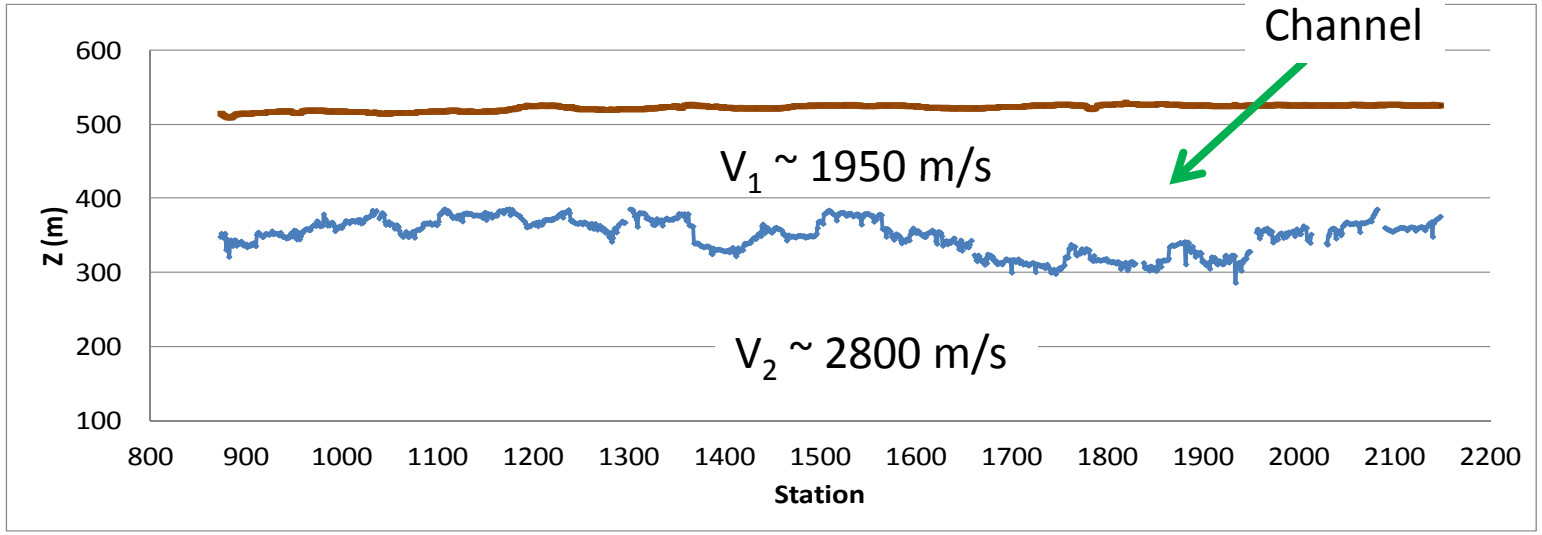


SH data



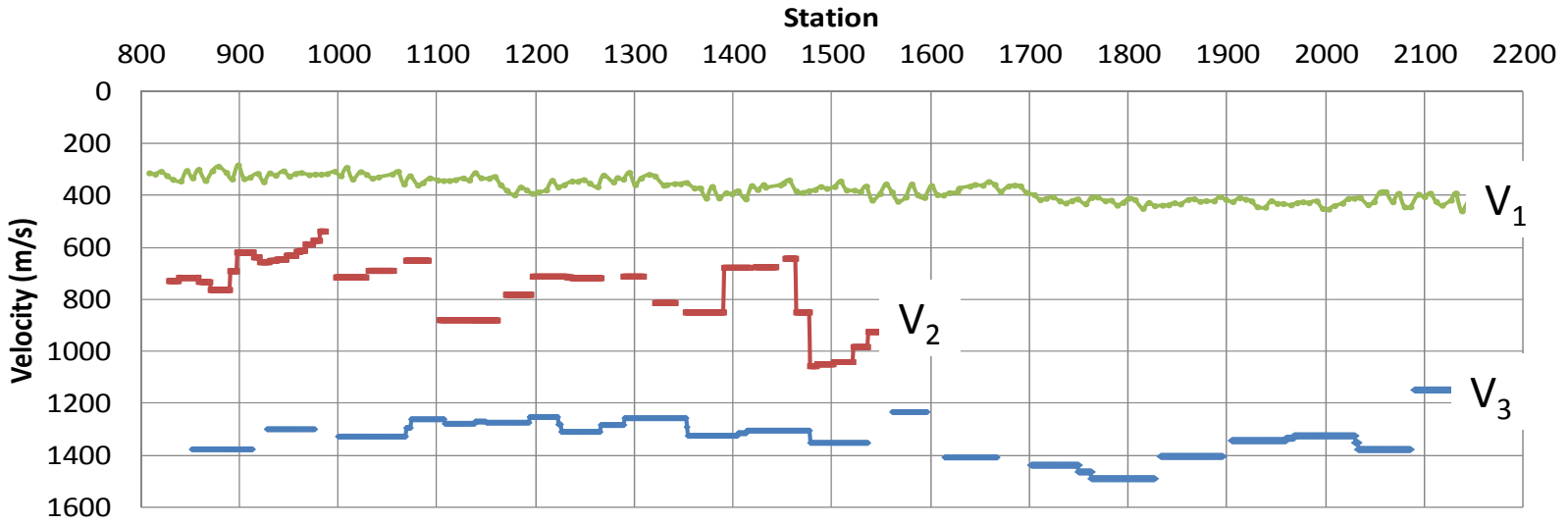
P-wave velocity & depth profile



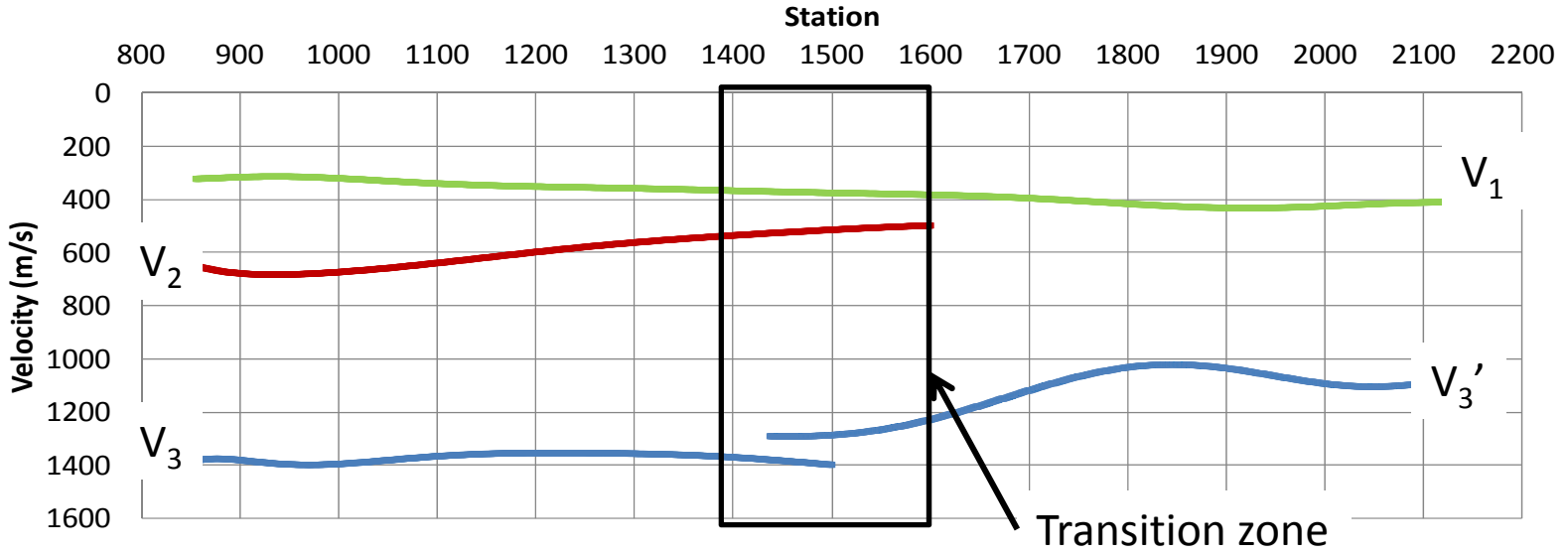


SH-wave data - velocity analysis

Manual

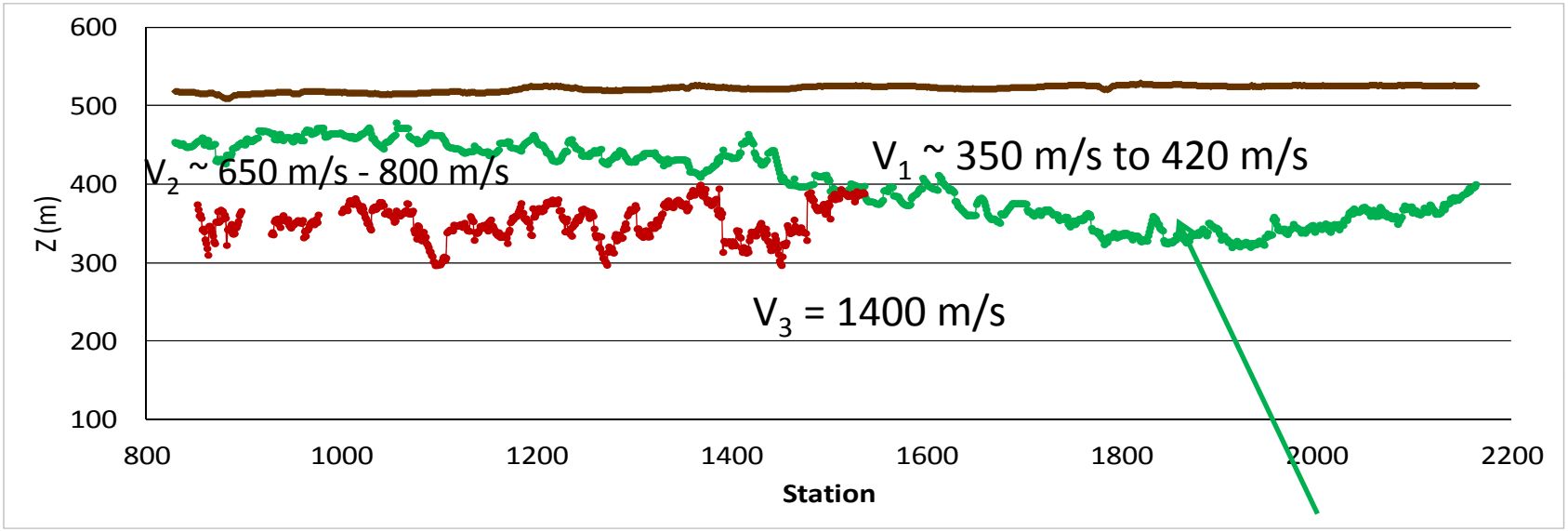


Automatic



SH-wave velocity & depth profile

Manual



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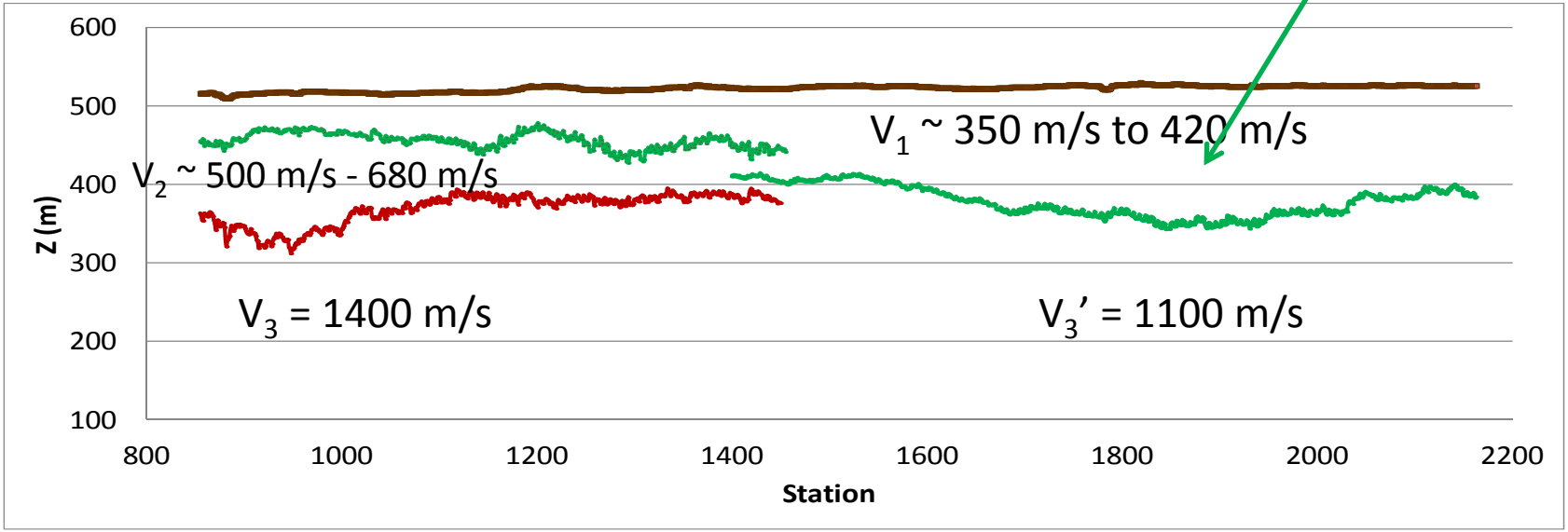
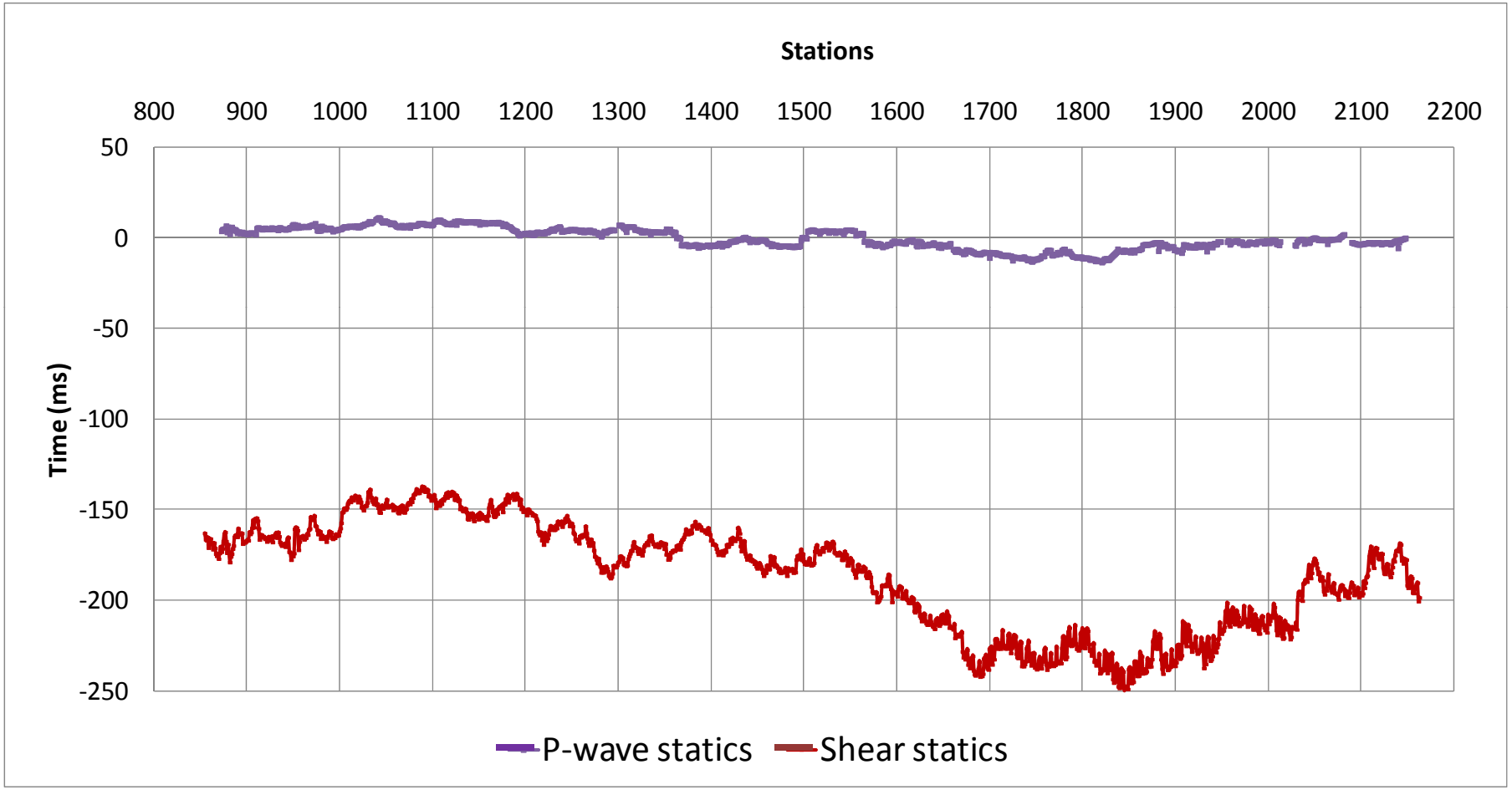


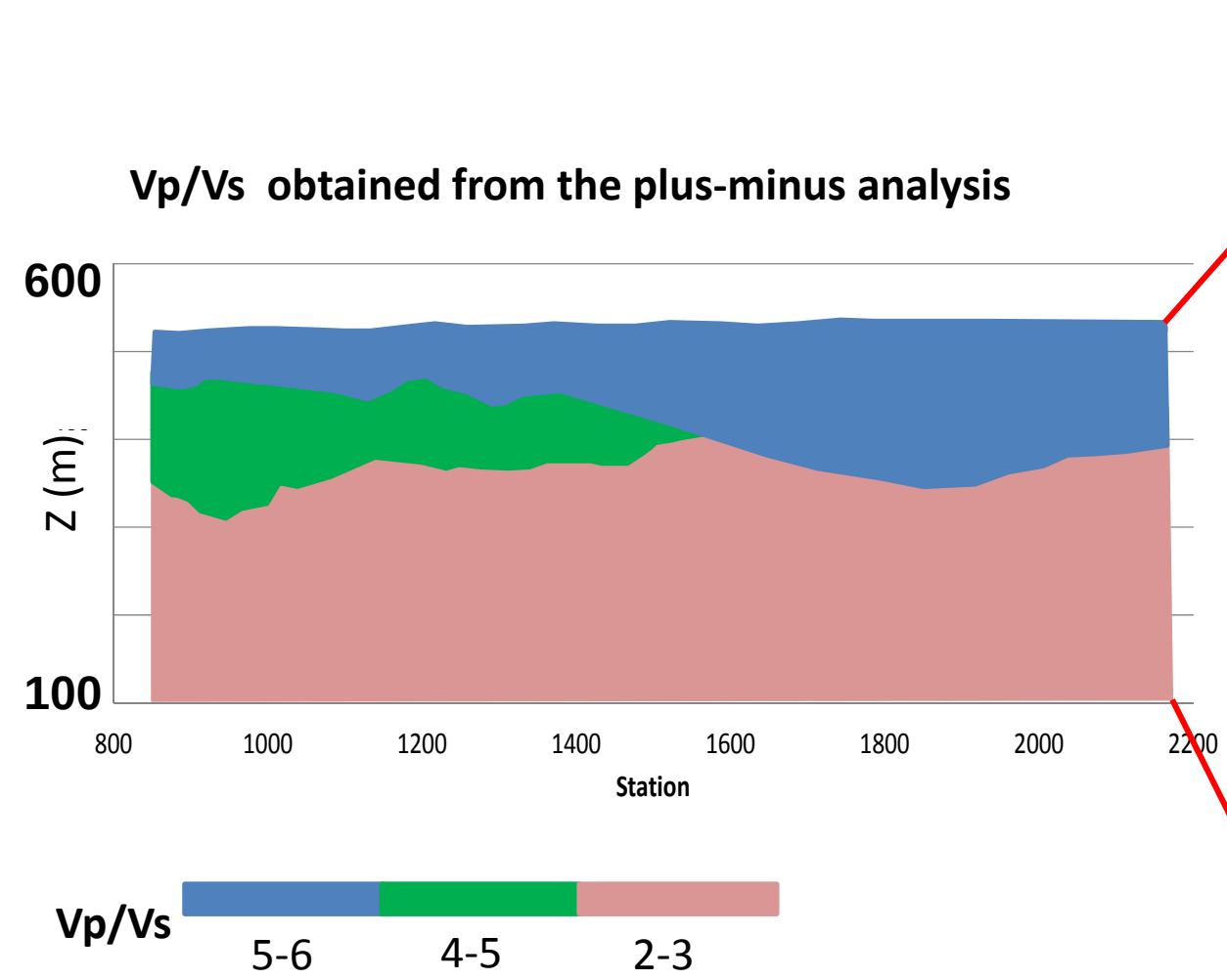
Receiver static corrections

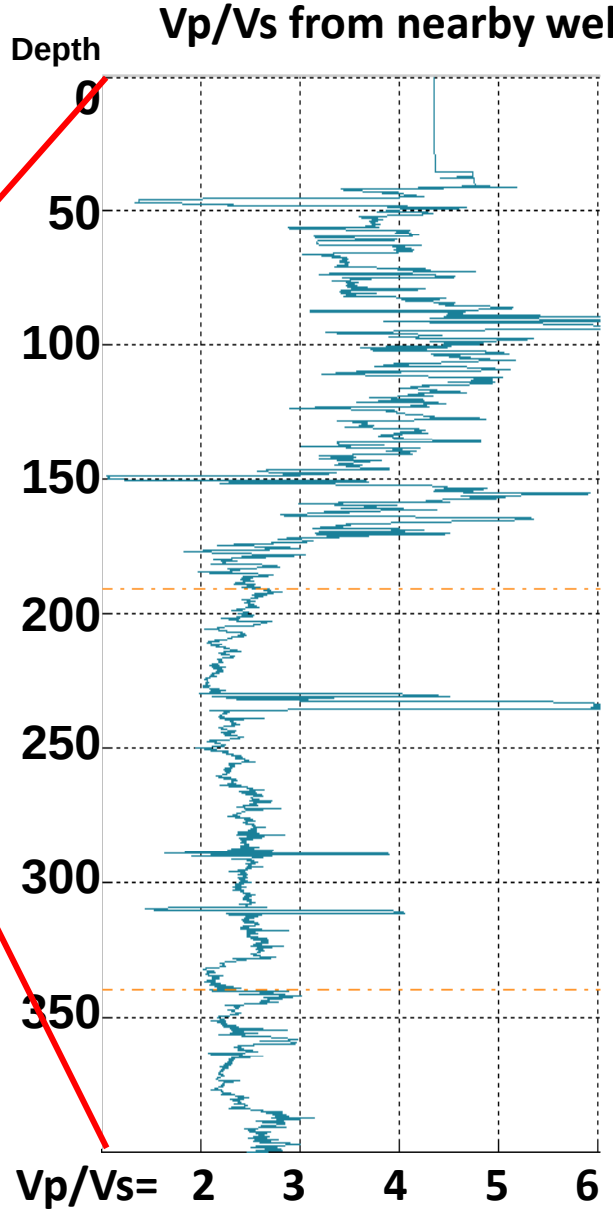


P wave data **Datum= 600 m** **V_r = 2800 m/s**

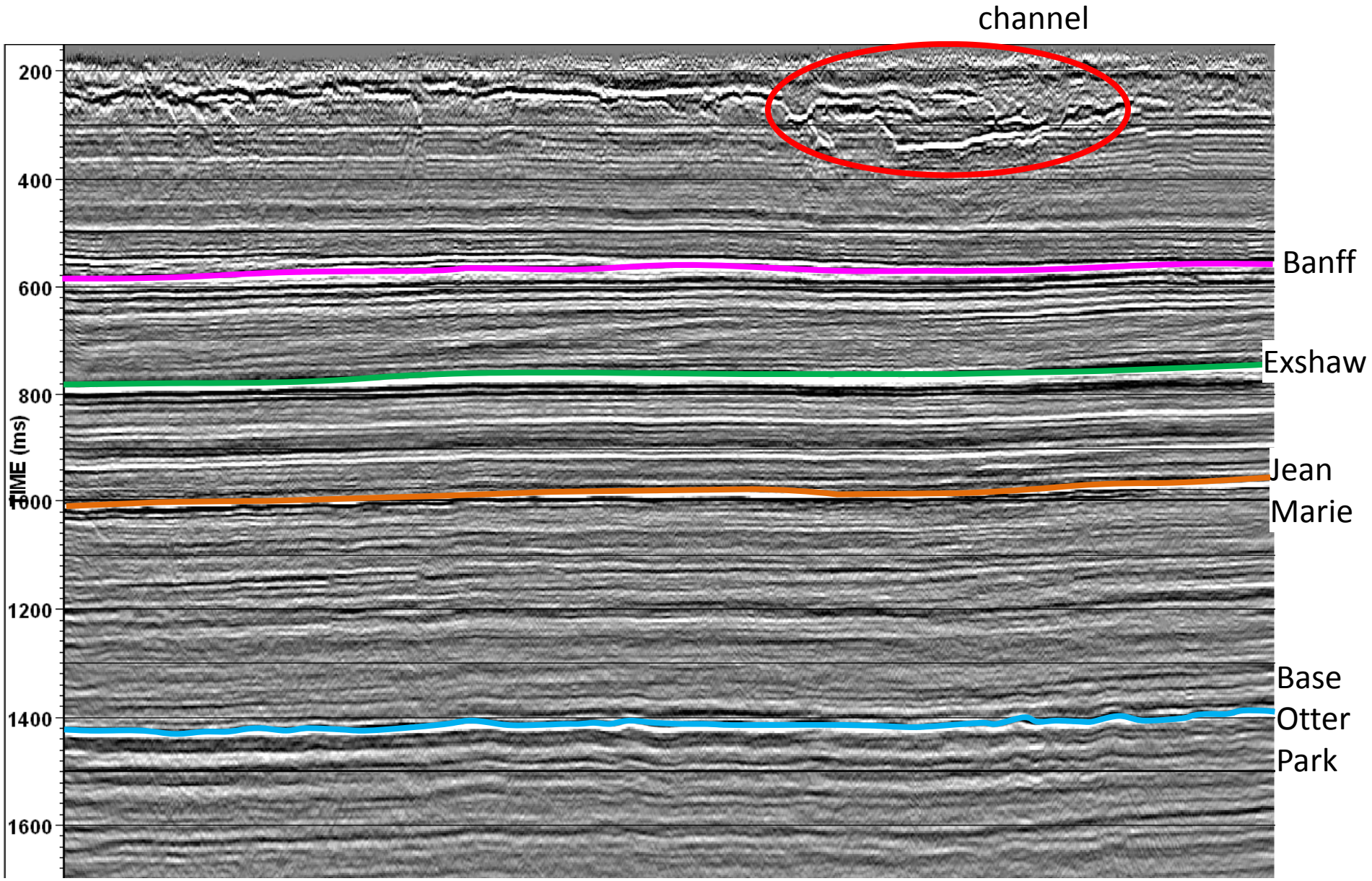
SH wave data **Datum = 600 m** **V_r = 1400 m/s**

Vp/Vs analysis

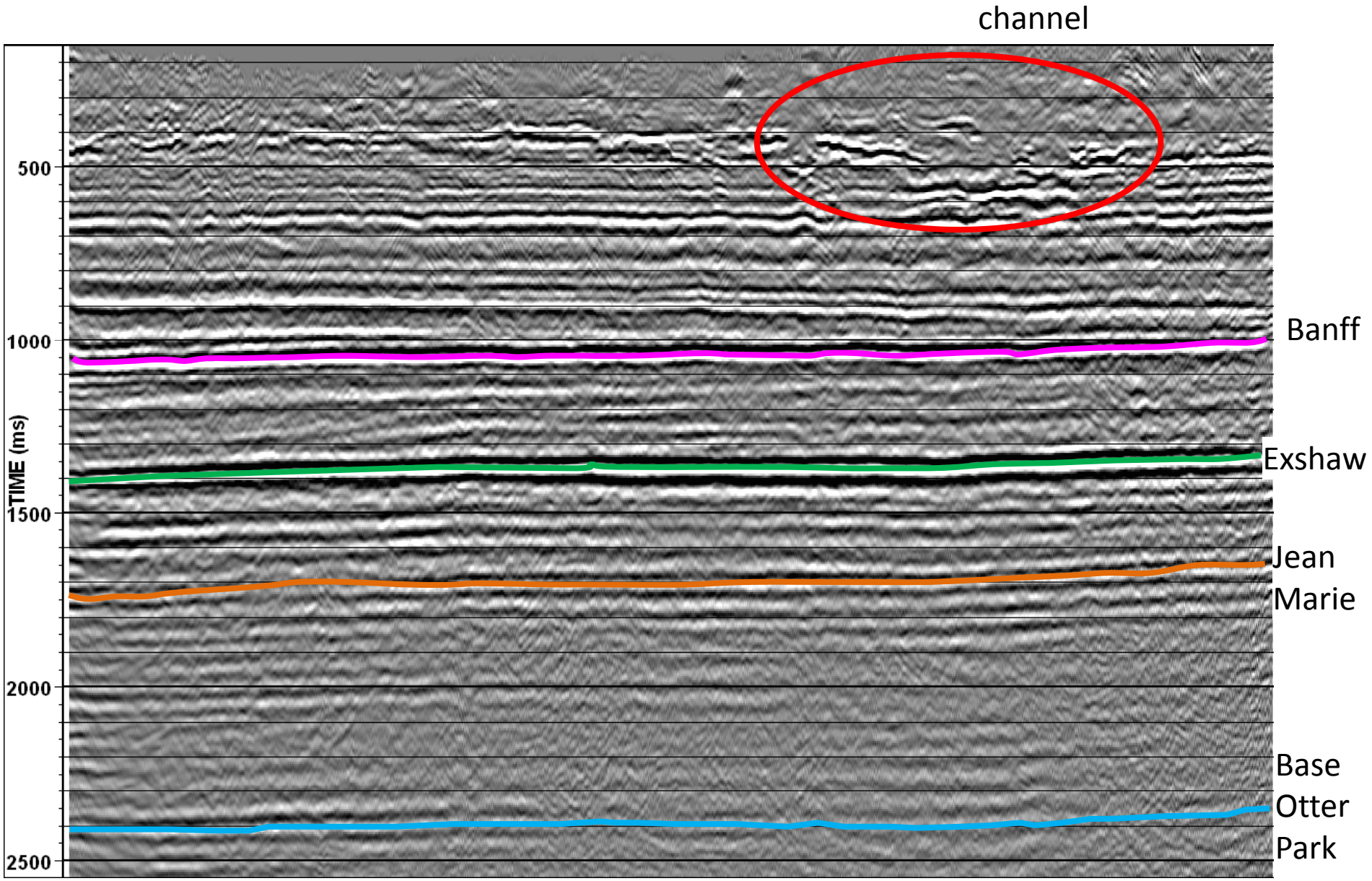




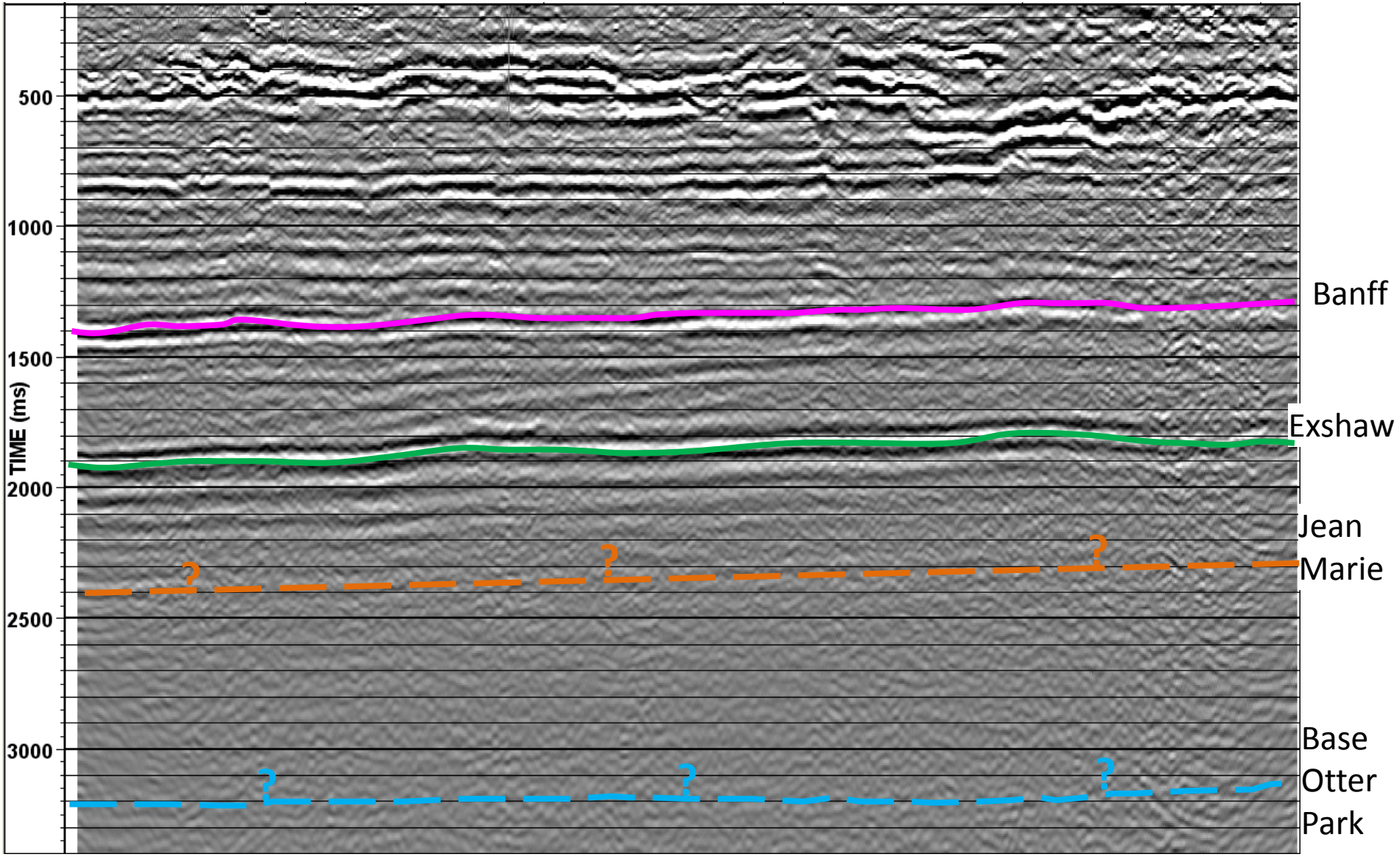
PP data


channel
200
400
600
800
1000
1200
1400
1600
TIME (ms)
Banff
Exshaw
Jean Marie
Base Otter Park

PS data


channel
500
1000
1500
2000
2500
TIME (ms)
Banff
Exshaw
Jean Marie
Base Otter Park

SH data


500
1000
1500
2000
2500
3000
TIME (ms)
Banff
Exshaw
Jean Marie
Base Otter Park
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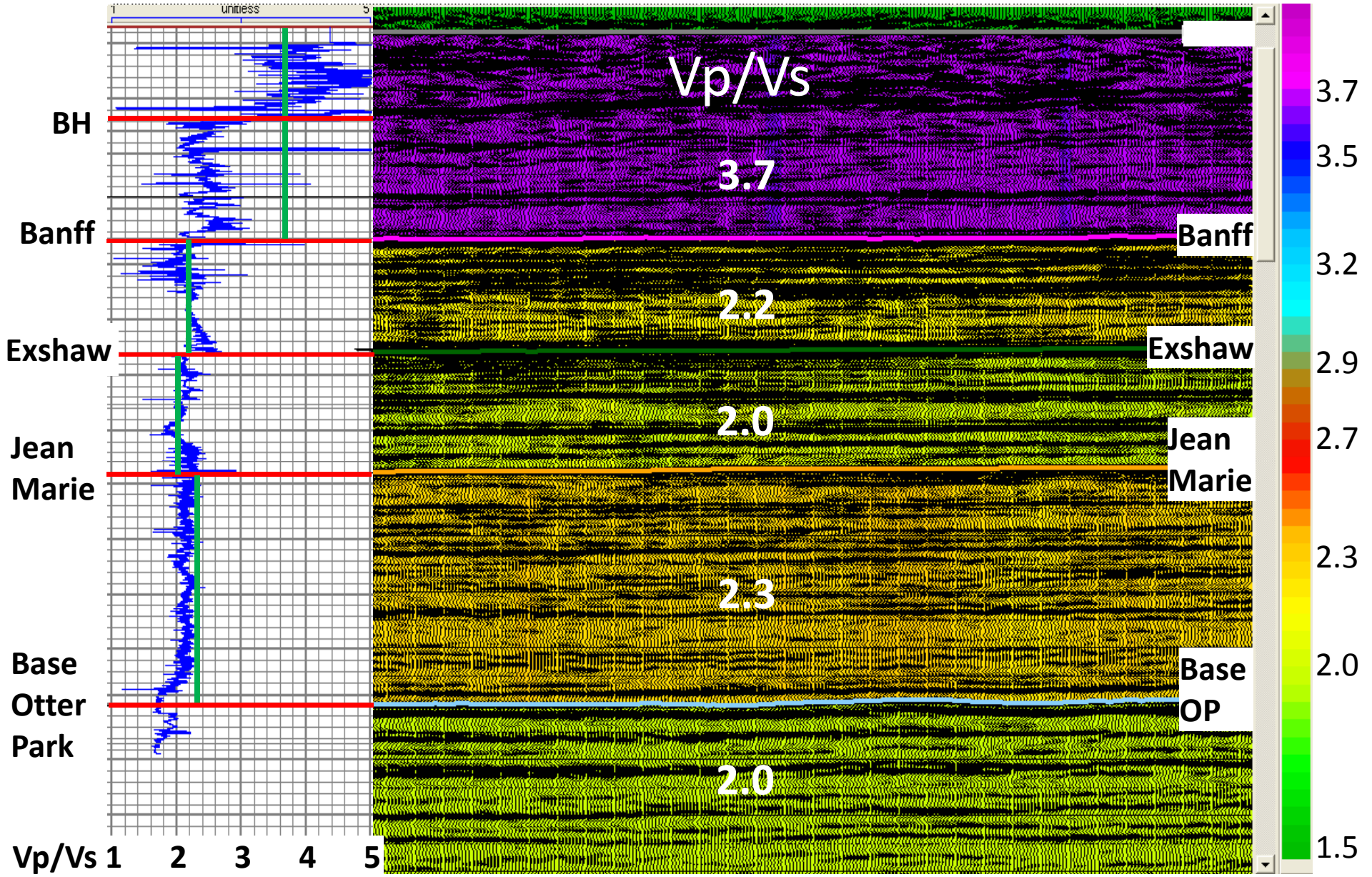
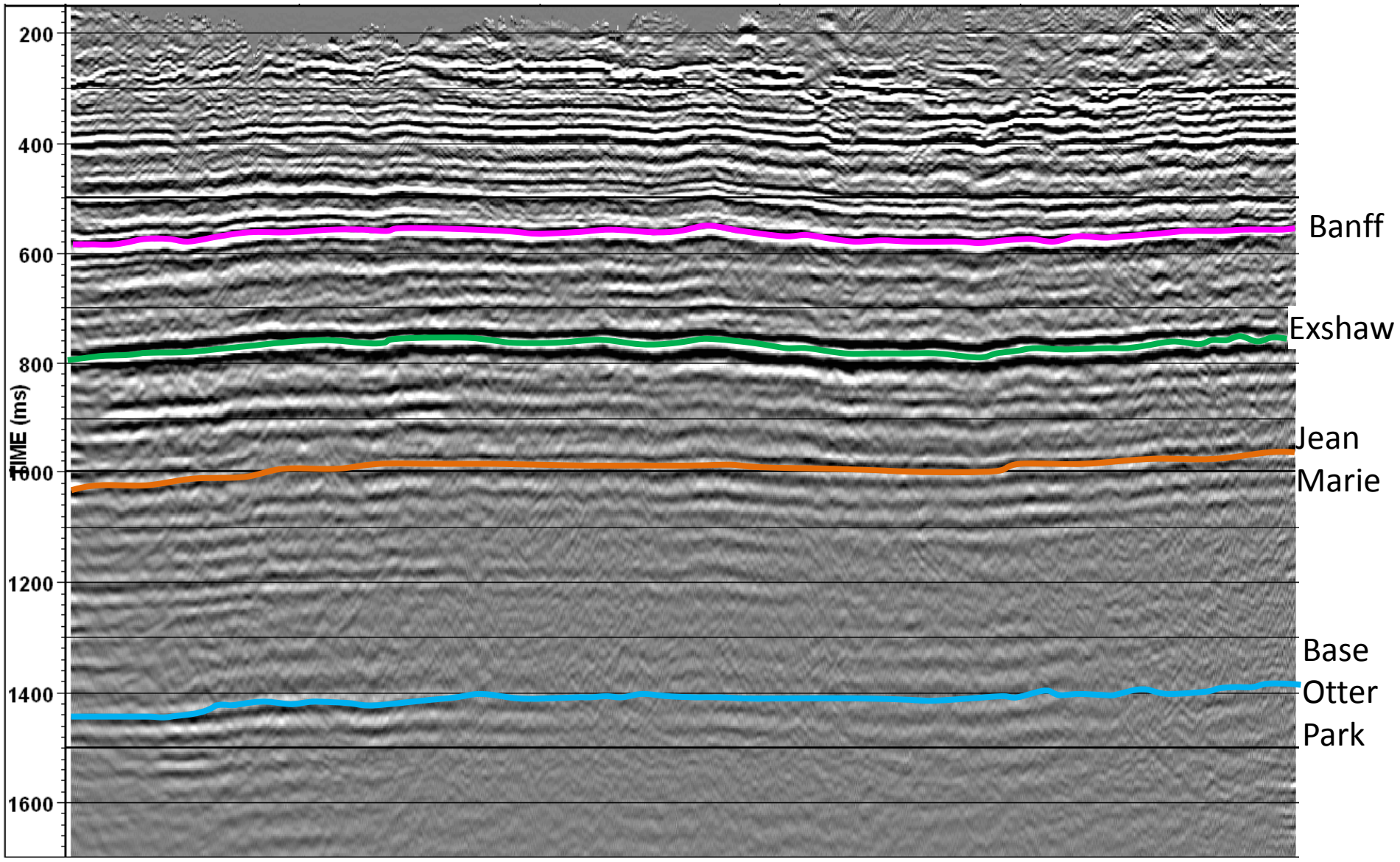
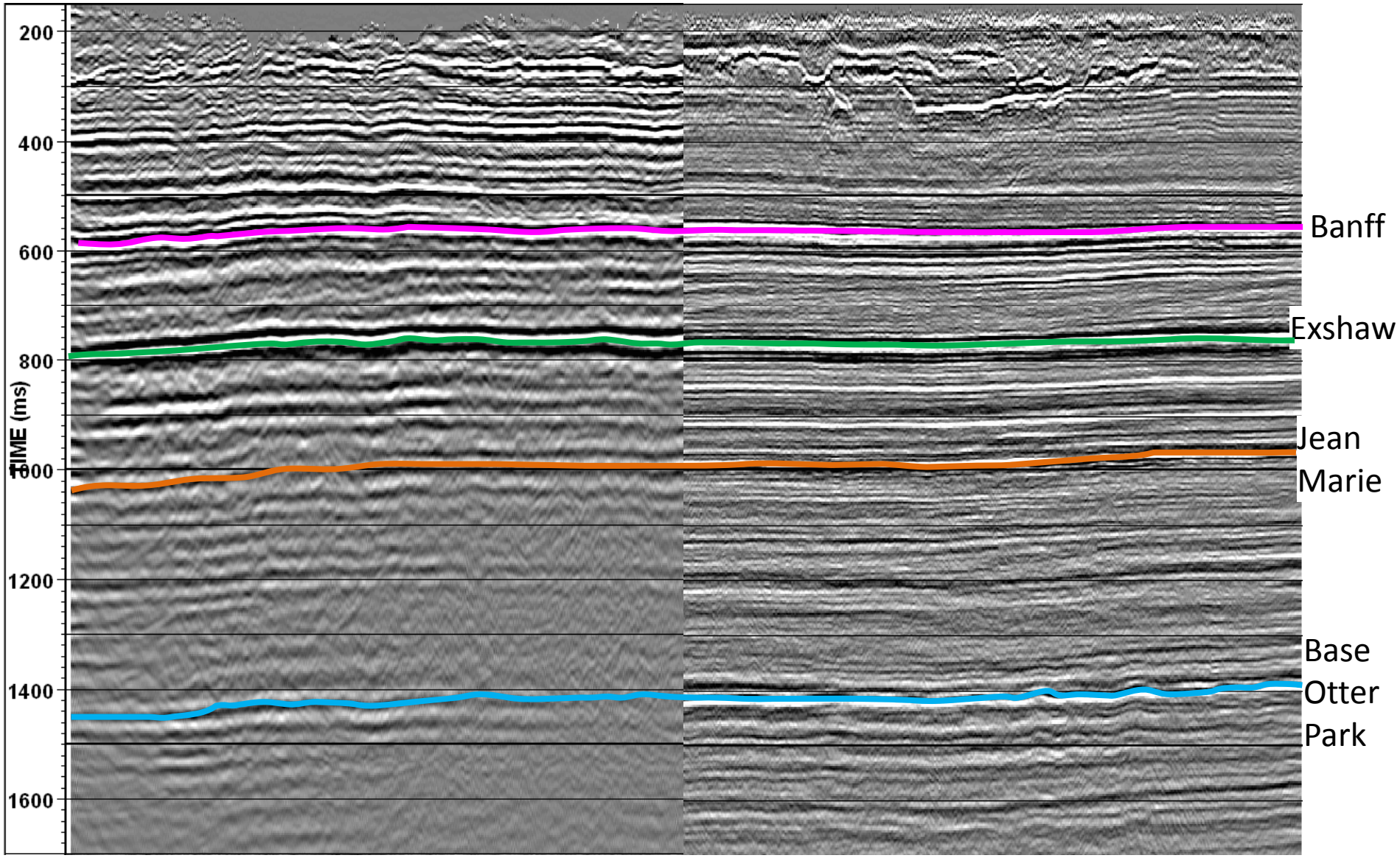
Vp/Vs after event registration



PS data in PP time



PS data vs PP data



Conclusions

- Different models were obtained from P-wave data and SH data due to more sensitivity of the shear data. For the P-wave, 1950 m/s and 2800 m/s were found for the first and second layer, respectively. For the SH-wave date, 350-420 m/s, 600-800 m/s and 1400 m/s for first, second and third layers, respectively
- The static correction times for SH-wave data are much greater than the static corrections times for P-wave data, as is expected. SH-wave statics range was -150 to -250 ms and P-wave statics varies from -15 ms to 15 ms.
- Well log information is very important in order to validate seismic reflectors on the data and to confirm PP and PS registration through comparison of Vp/VS.

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