Source signature estimation for ocean bottom data

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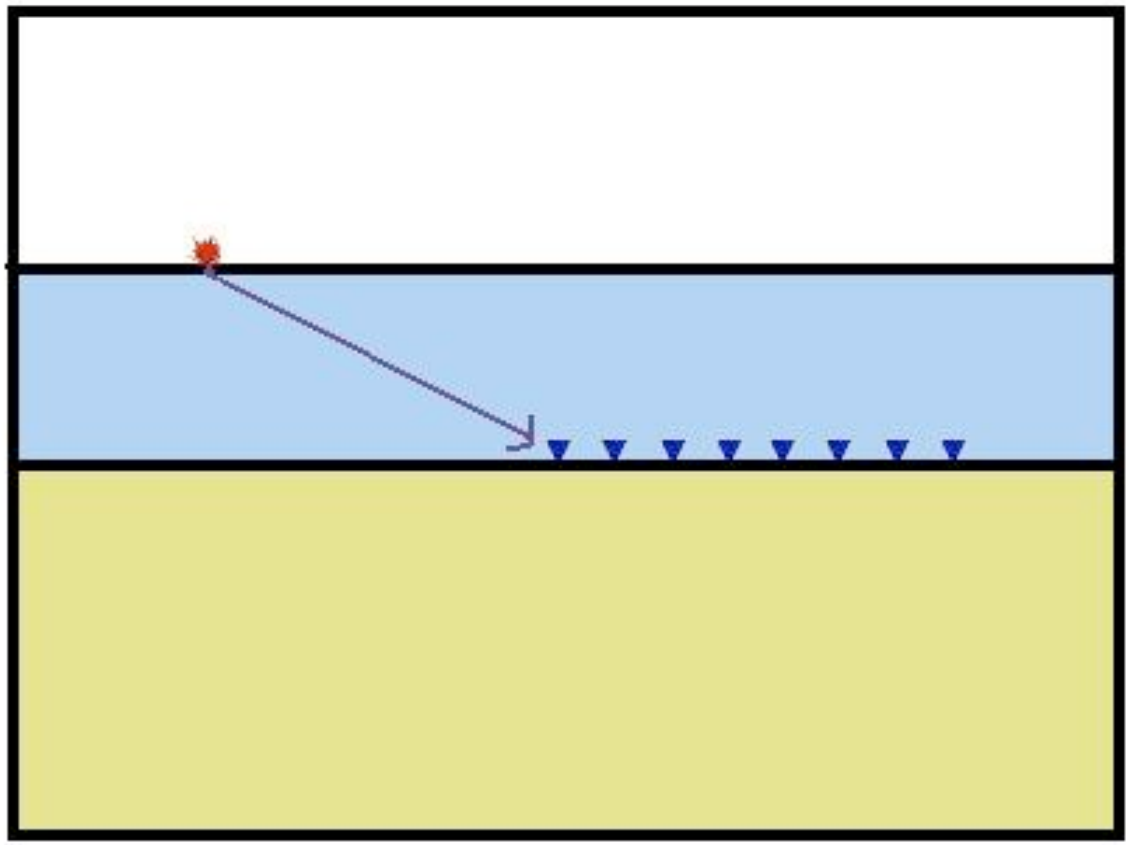
SEP138, pp 223-232

Mandy Wong

Overview

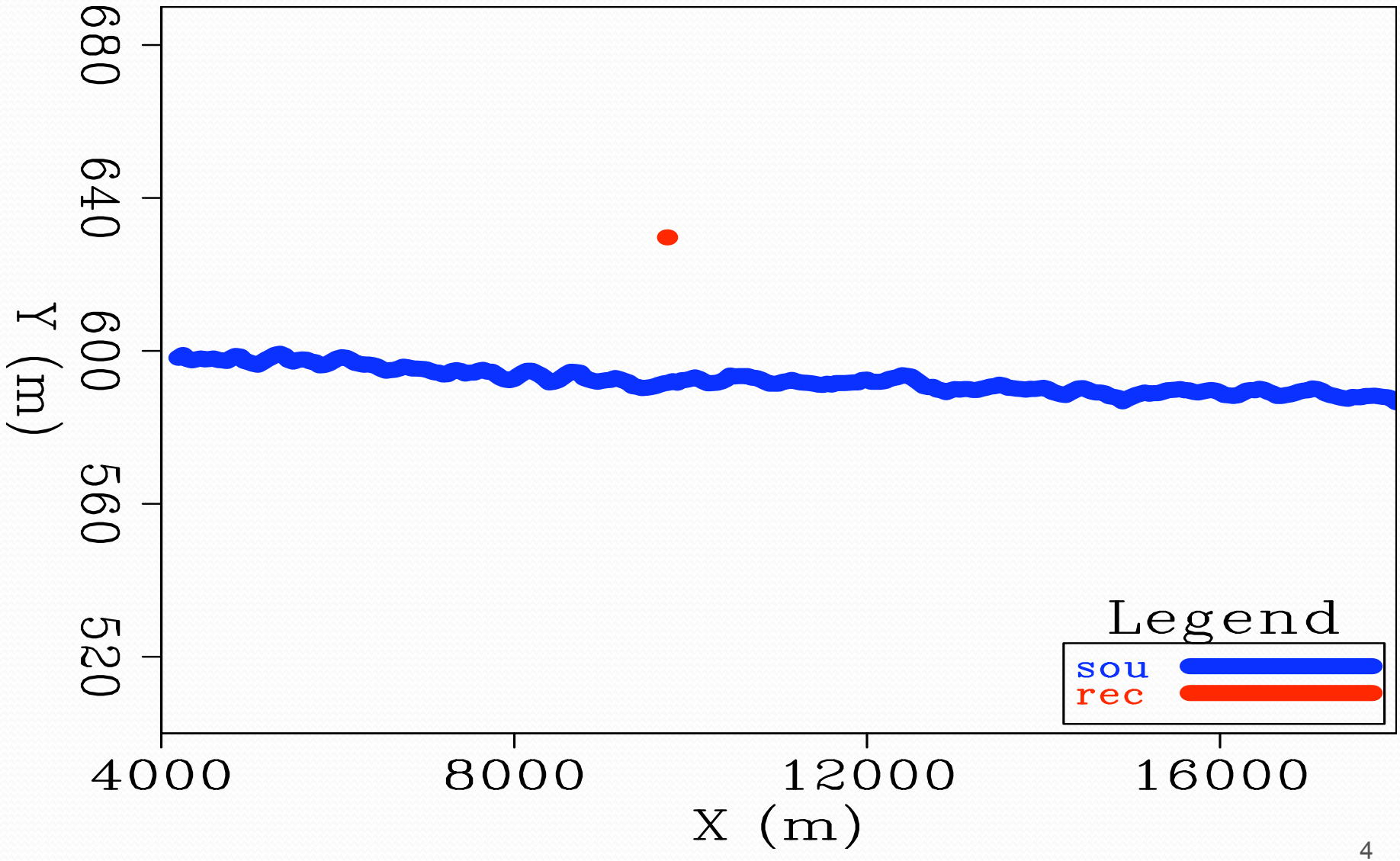
- Introduction
- Ocean Bottom Nodes dataset
  - Common Receiver Gather
  - Spectra/ Notch Frequency
- Source signature extraction
  - PZ summation
  - Result
- Conclusion

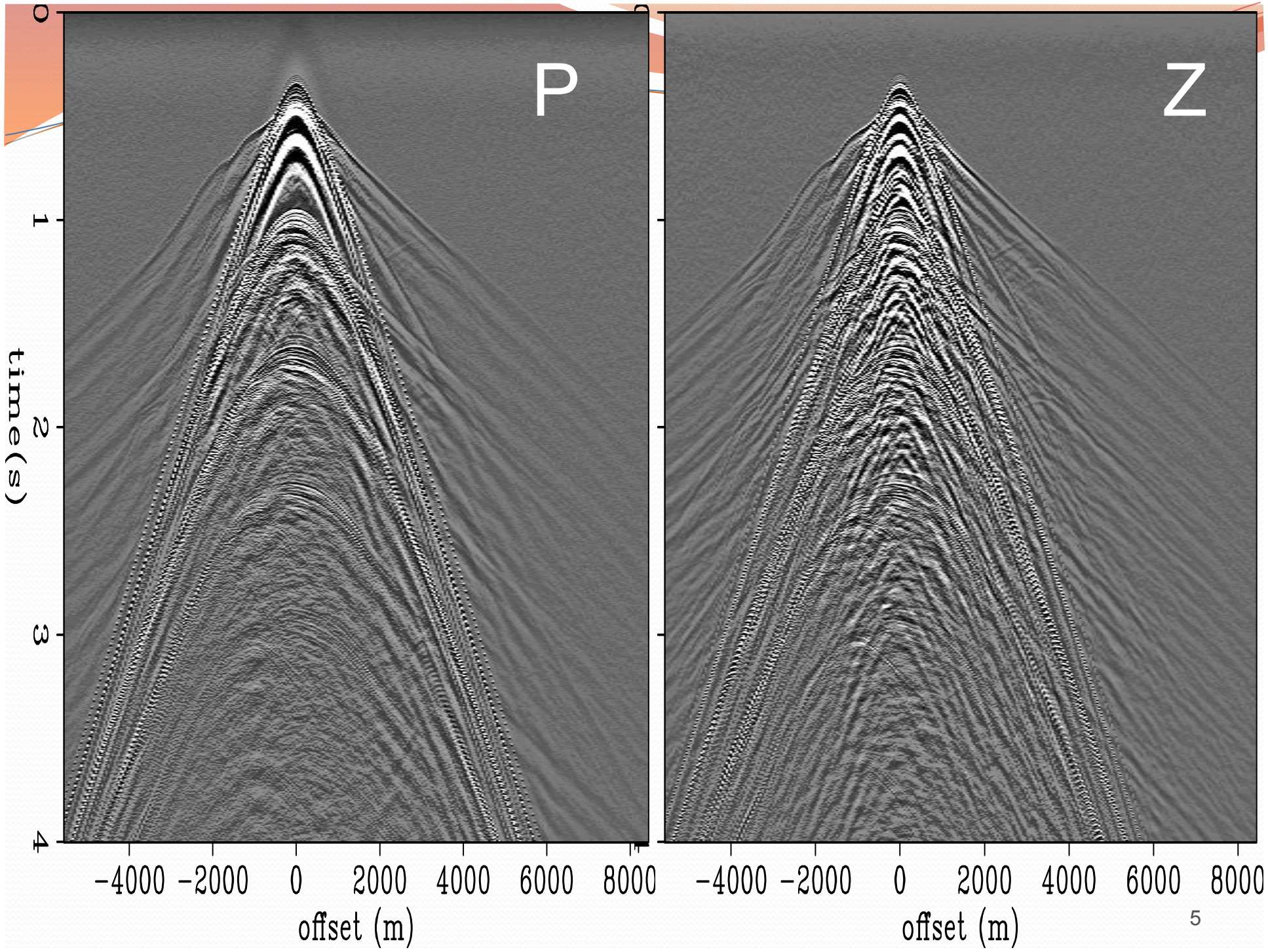
Introduction

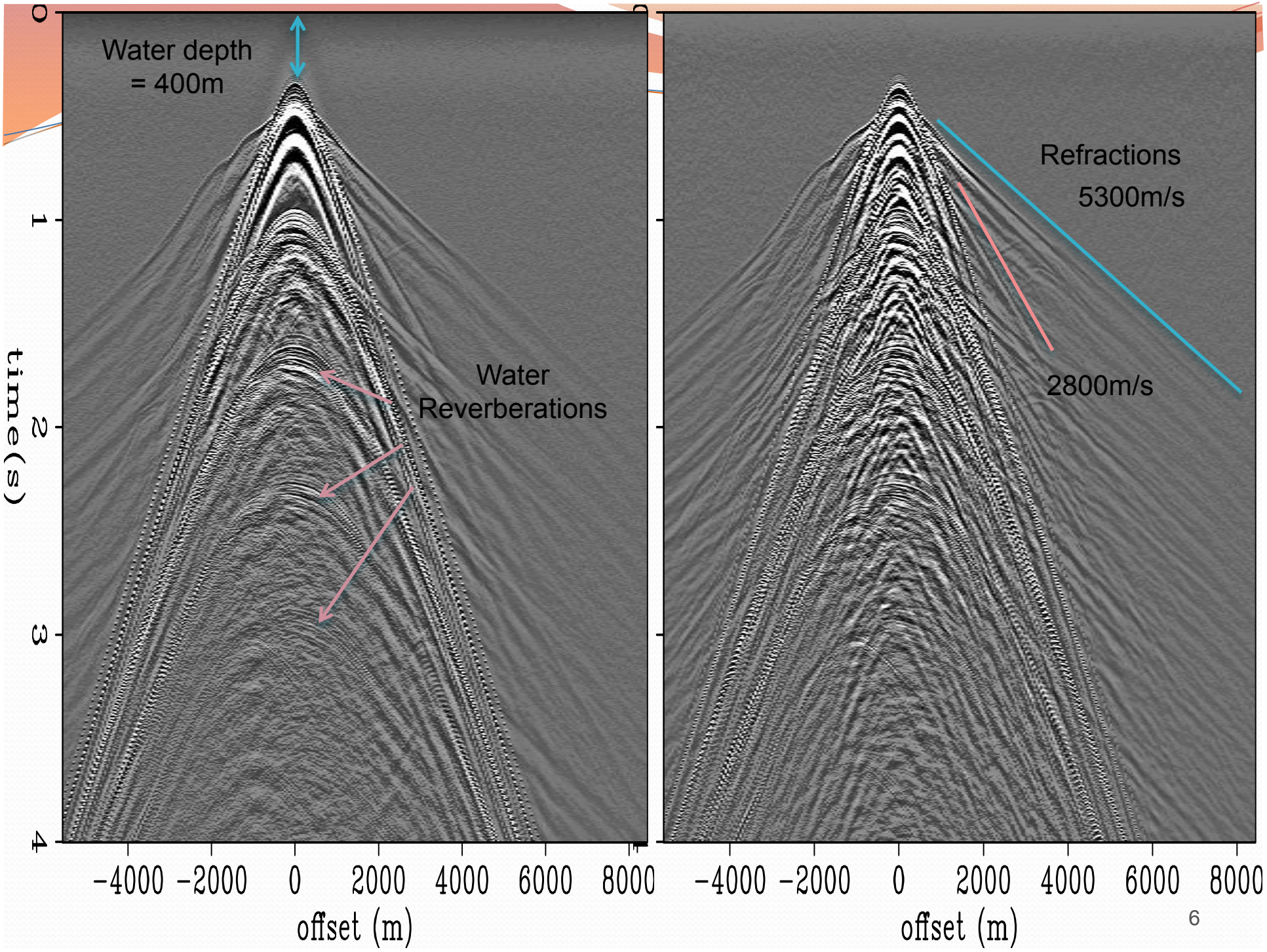


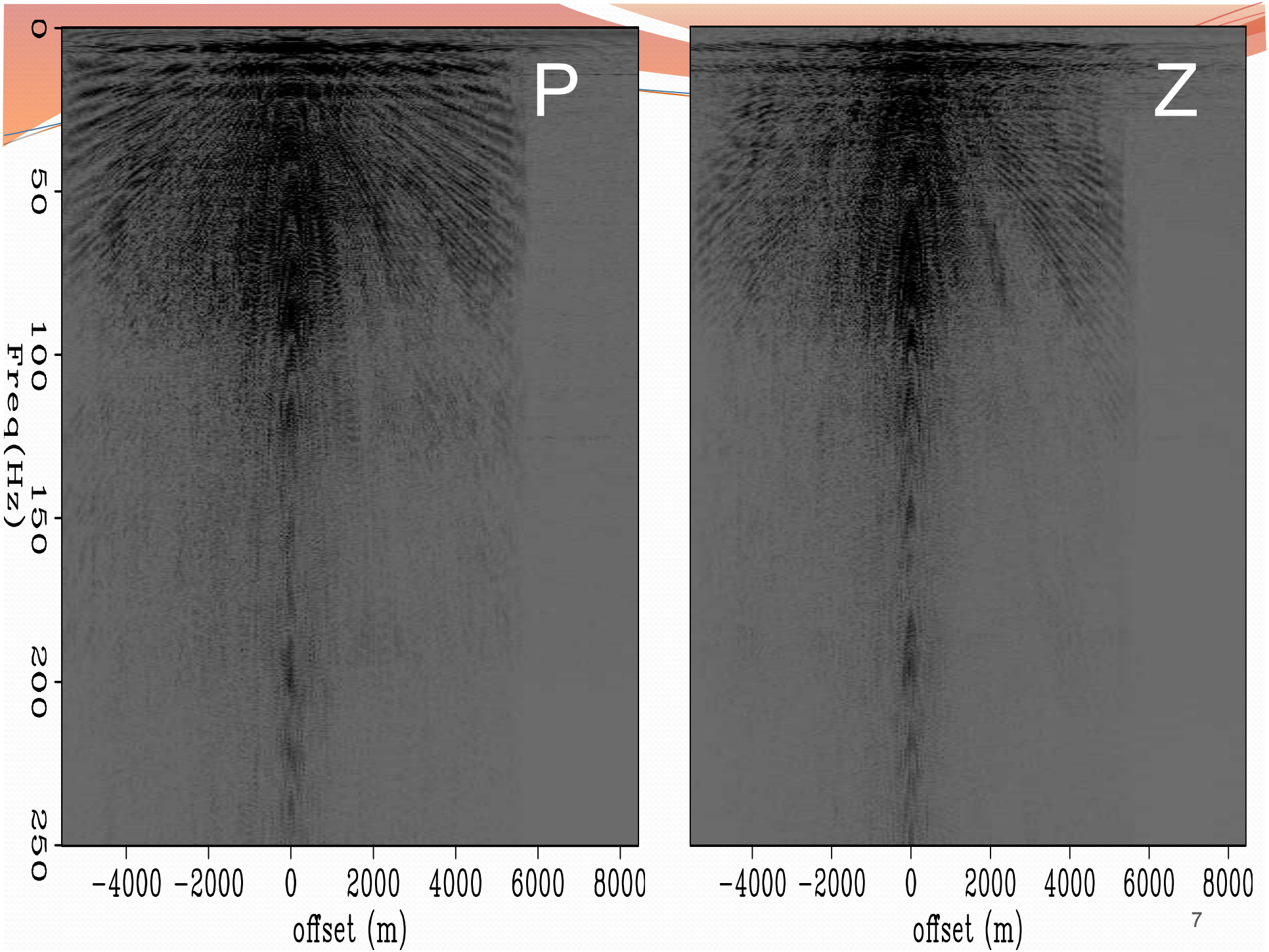
Ocean Bottom Nodes (OBN) Dataset

Map view of source and receiver locations

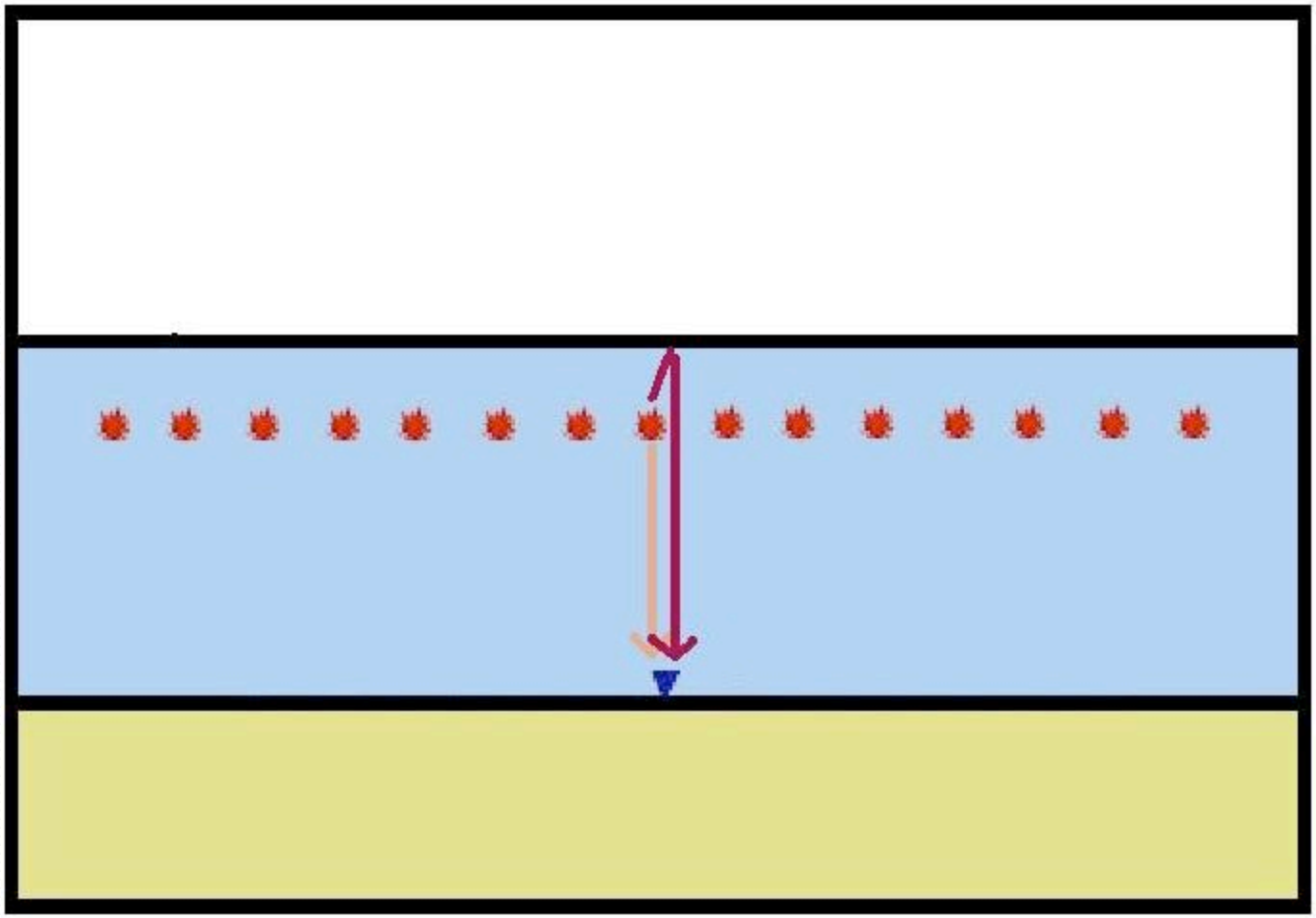



P
Z
time(s)
0
1
2
3
4
-4000
-2000
0
2000
4000
6000
8000
offset (m)

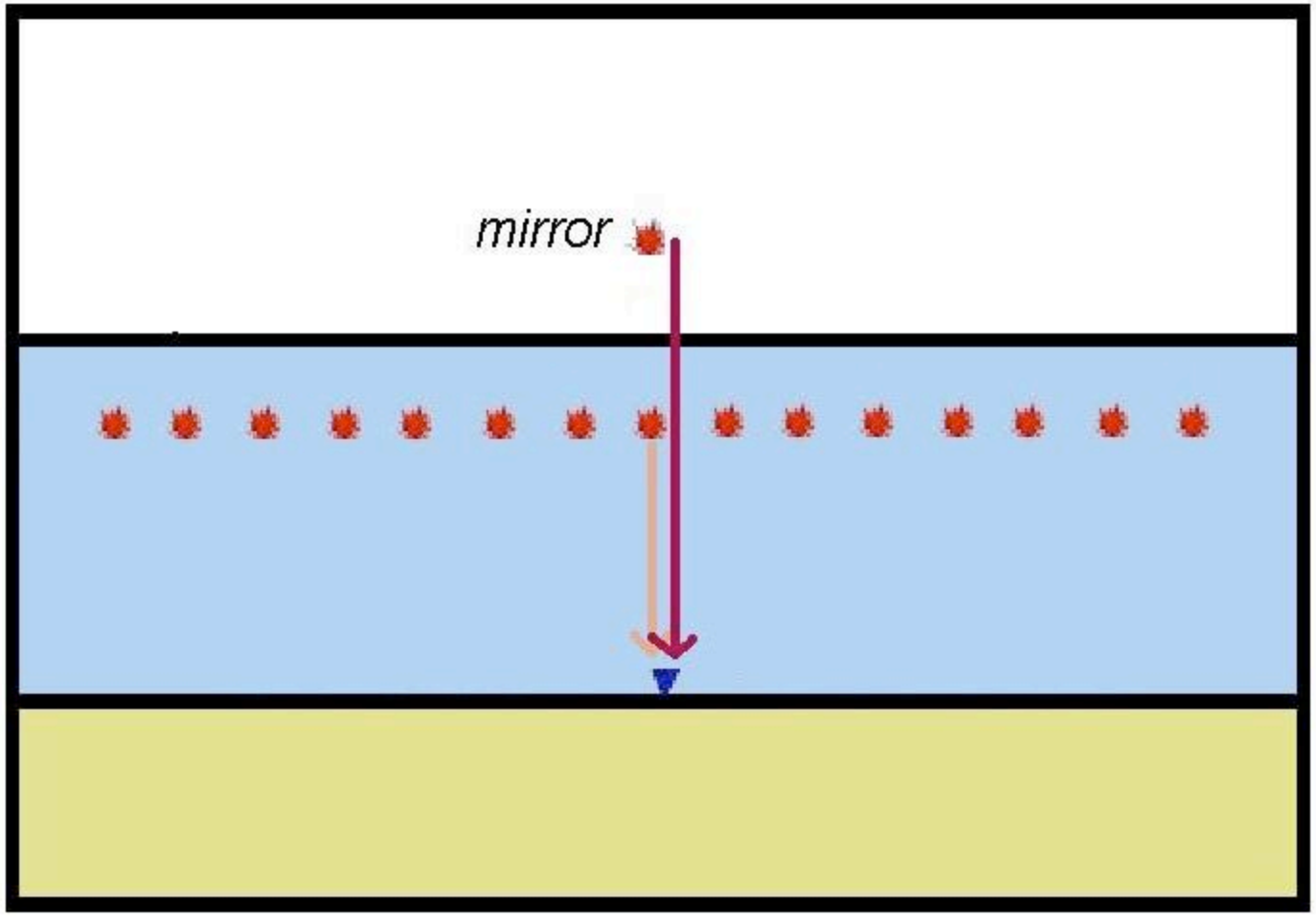

Water depth
= 400m
Water
Reverberations
Refractions
5300m/s
2800m/s
time (s)
0
1
2
3
4
-4000
-2000
0
2000
4000
6000
8000
offset (m)


P
Z
0
50
100
150
200
250
Freq(Hz)
-4000
-2000
0
2000
4000
6000
8000
offset (m)
-4000
-2000
0
2000
4000
6000
8000
offset (m)

Notch frequencies



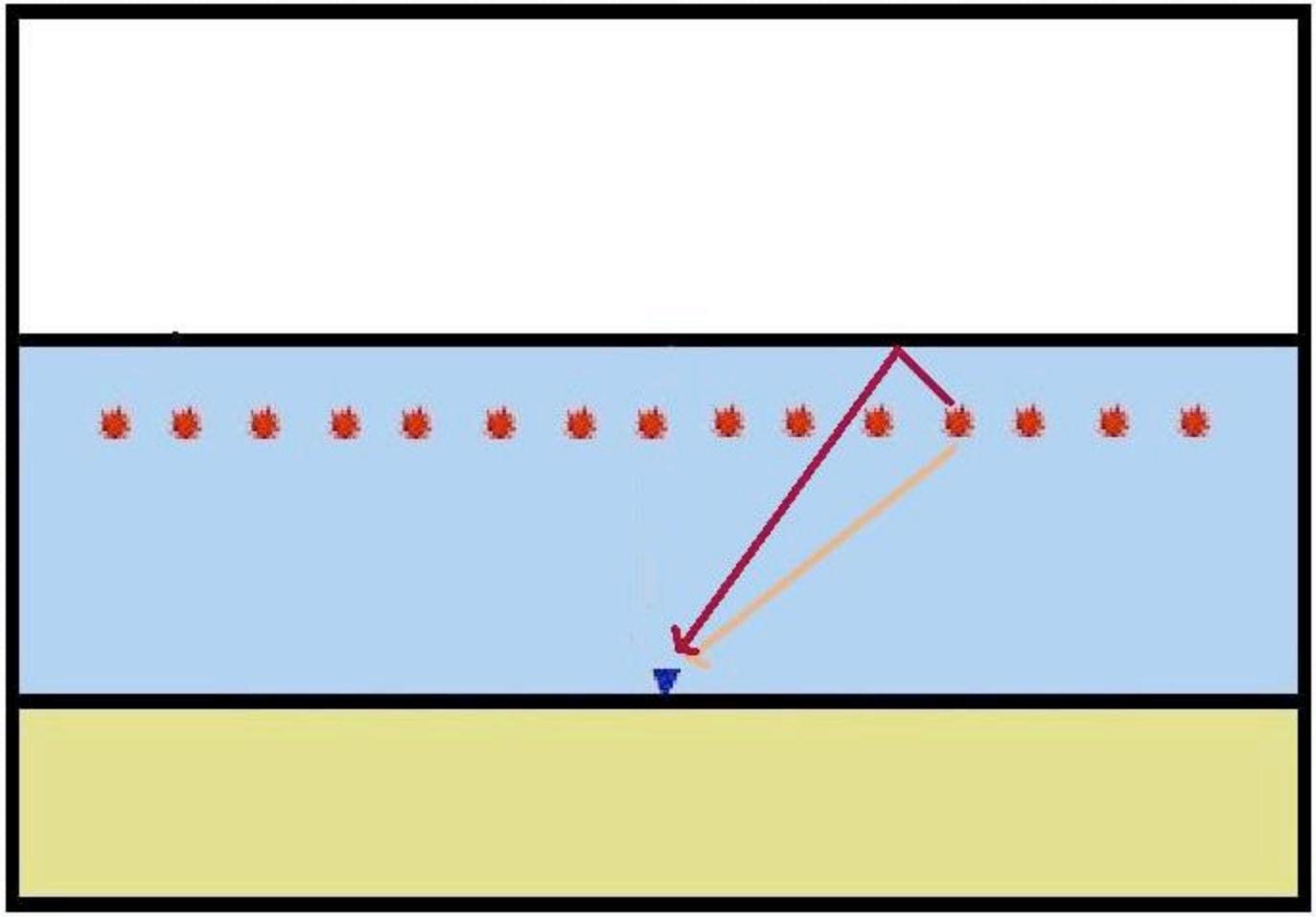
Notch frequencies



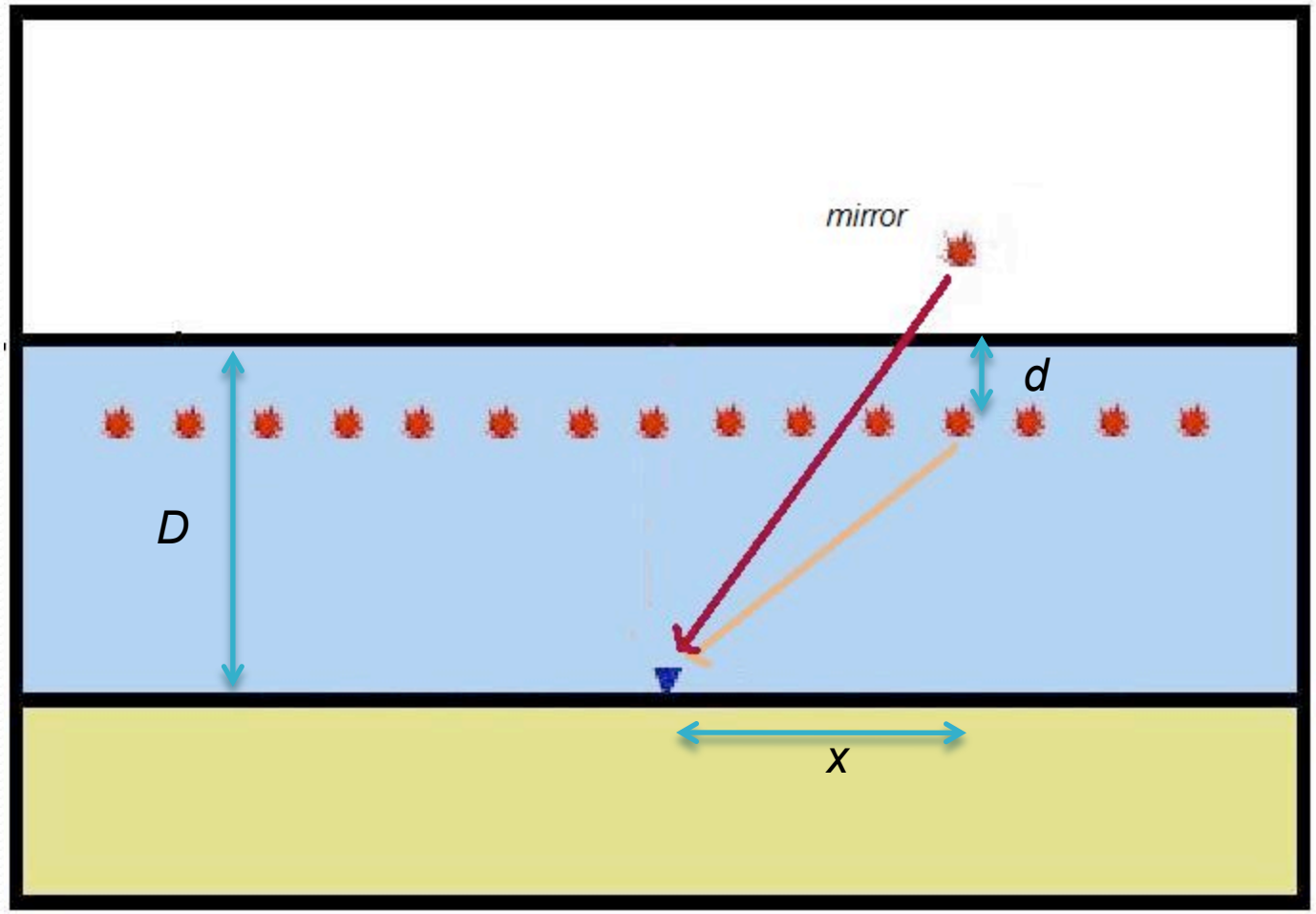
$$f_n = \frac{nv}{2d}$$

d = shot depth
v = water velocity
fn = notch freq

Notch frequencies

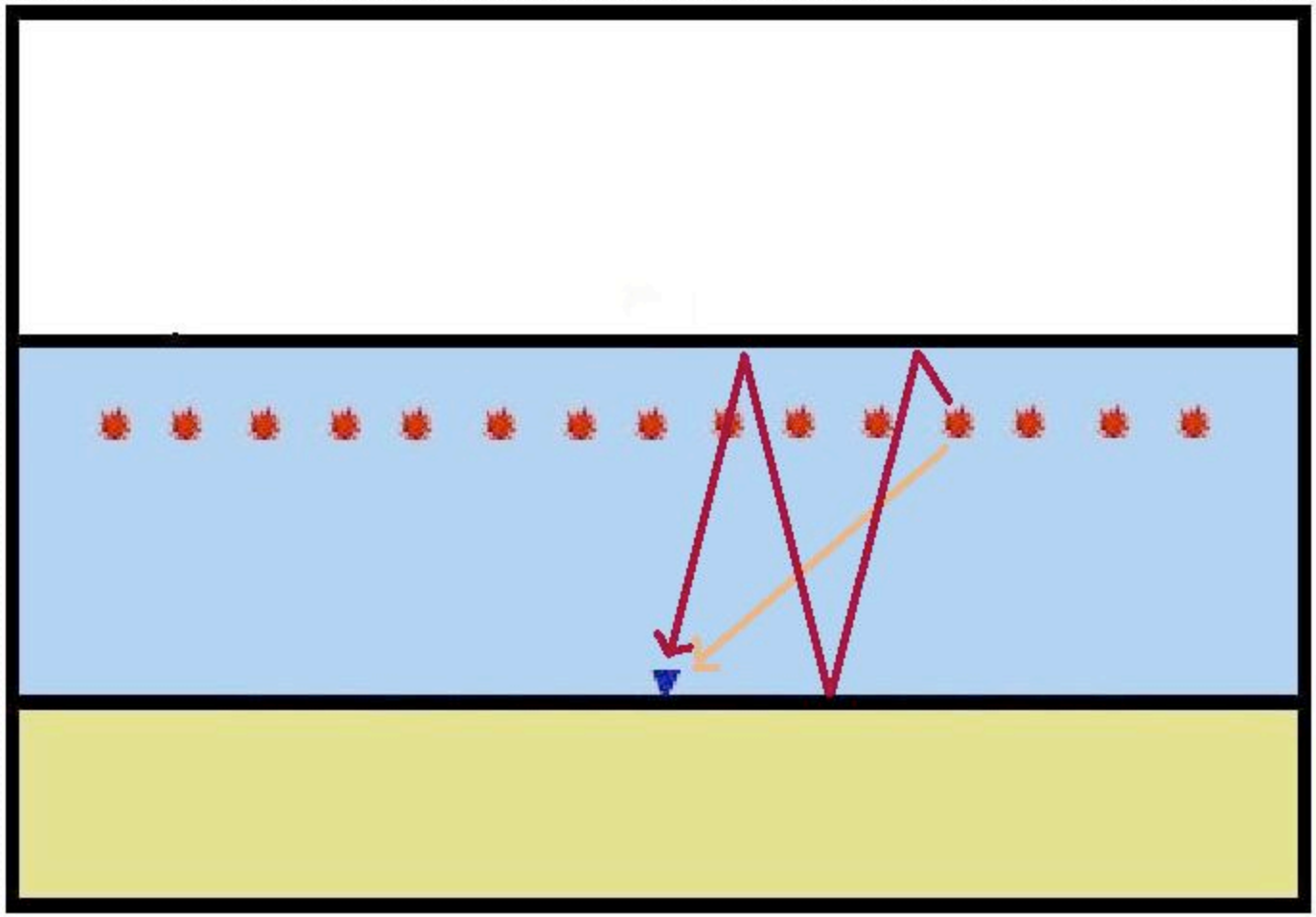


Notch frequencies

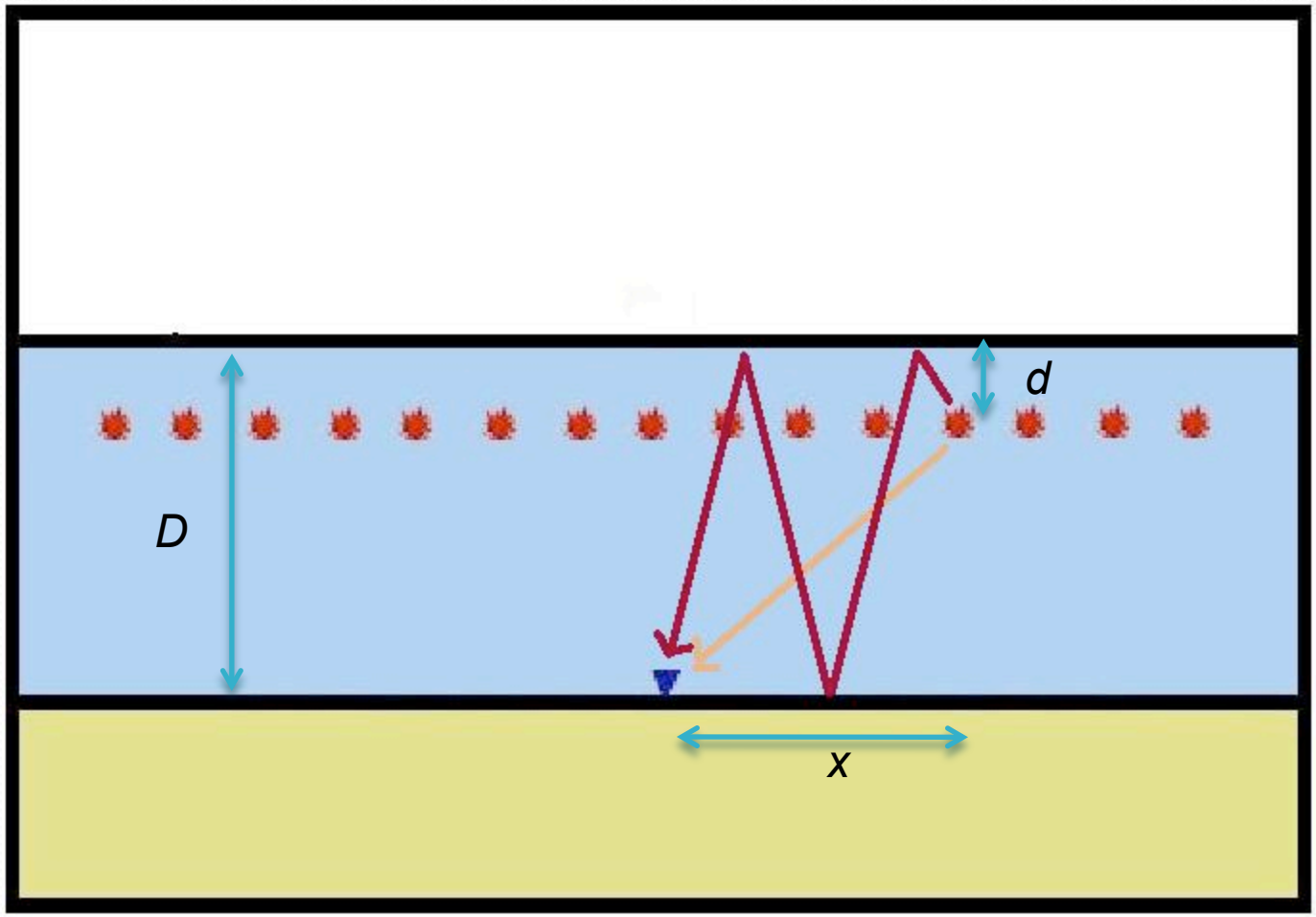


$$f_n(x) = \frac{nv}{\sqrt{(D+d)^2 + x^2} - \sqrt{(D-d)^2 + x^2}}$$

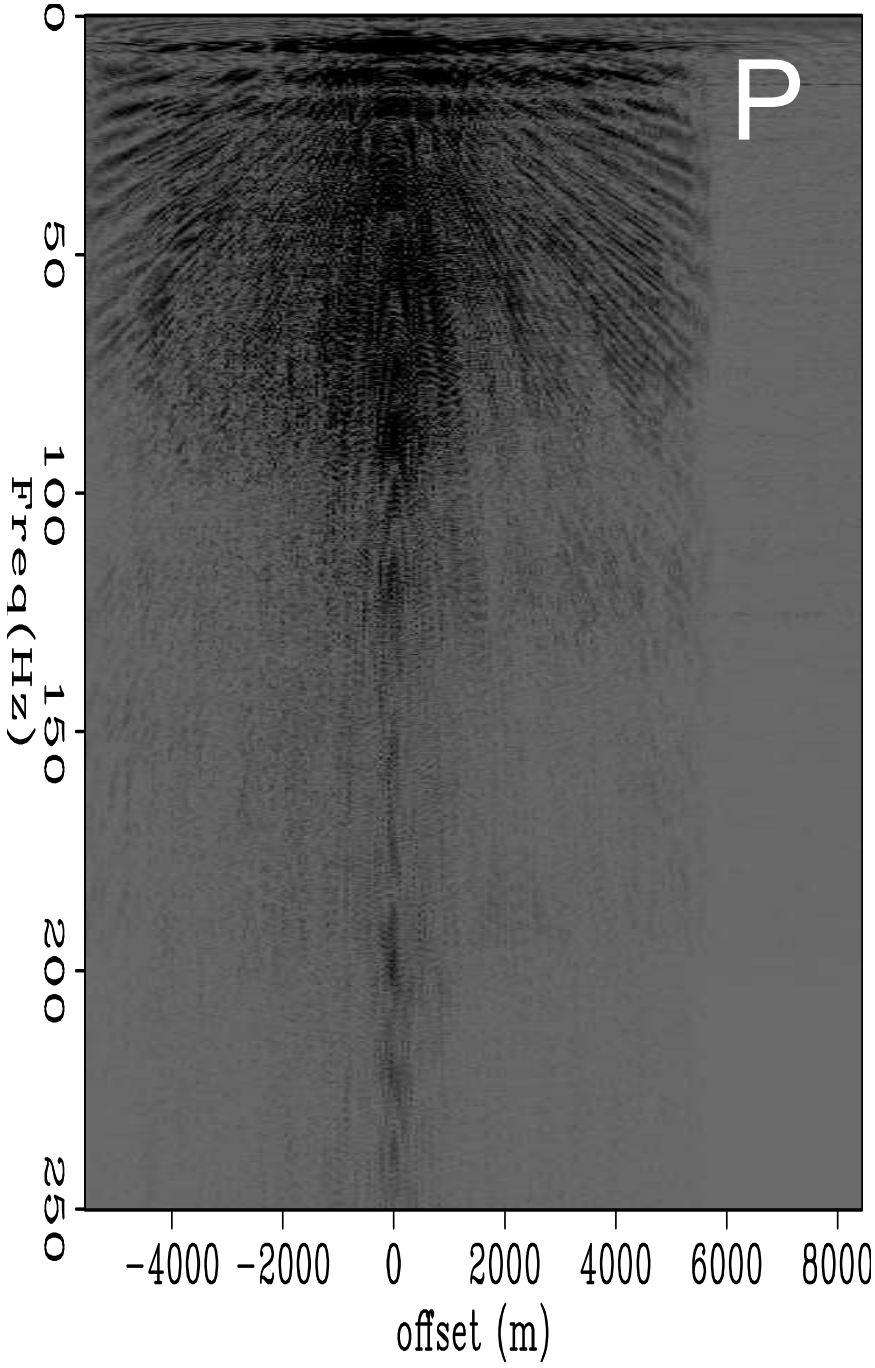
Notch frequencies

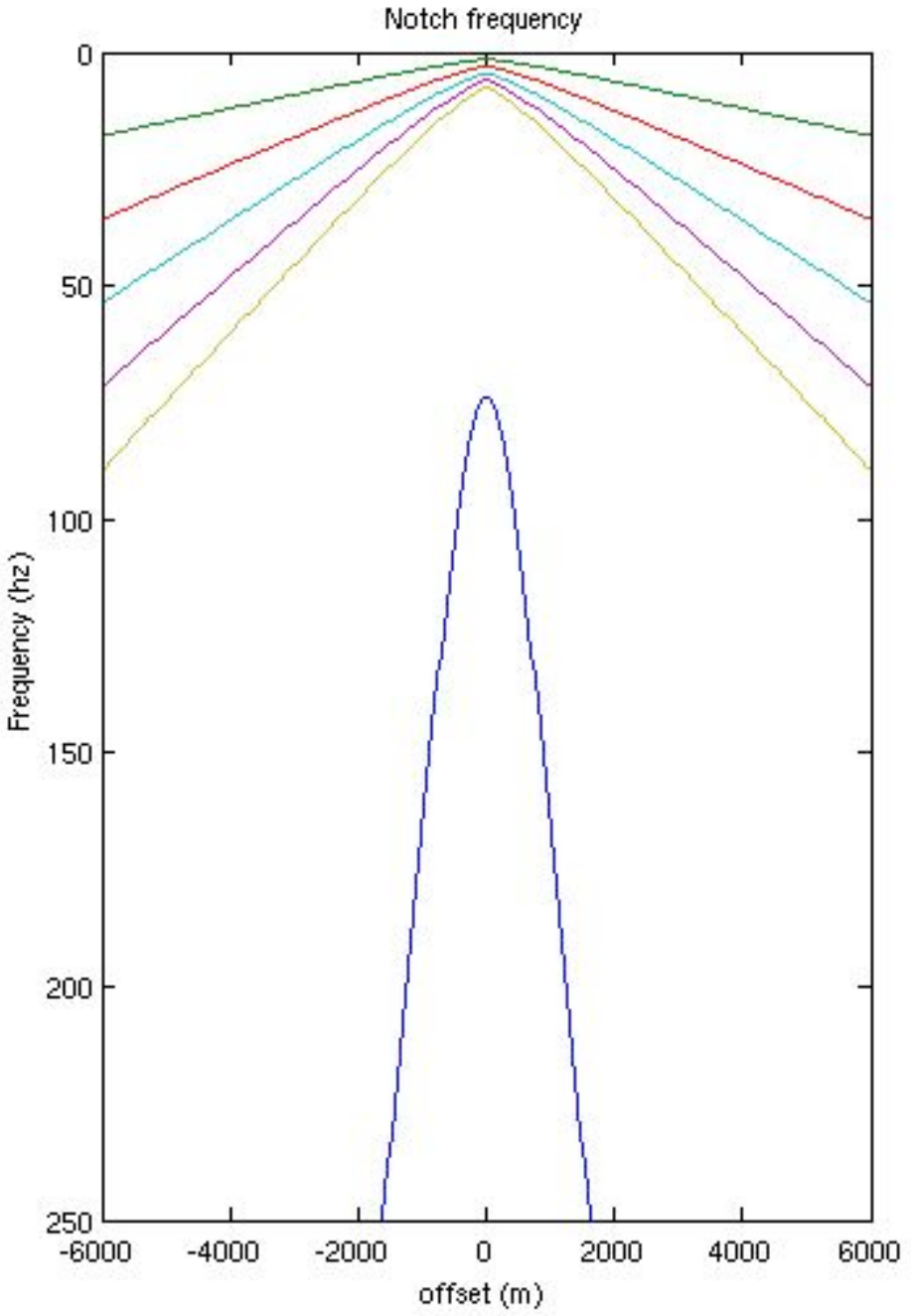


Notch frequencies

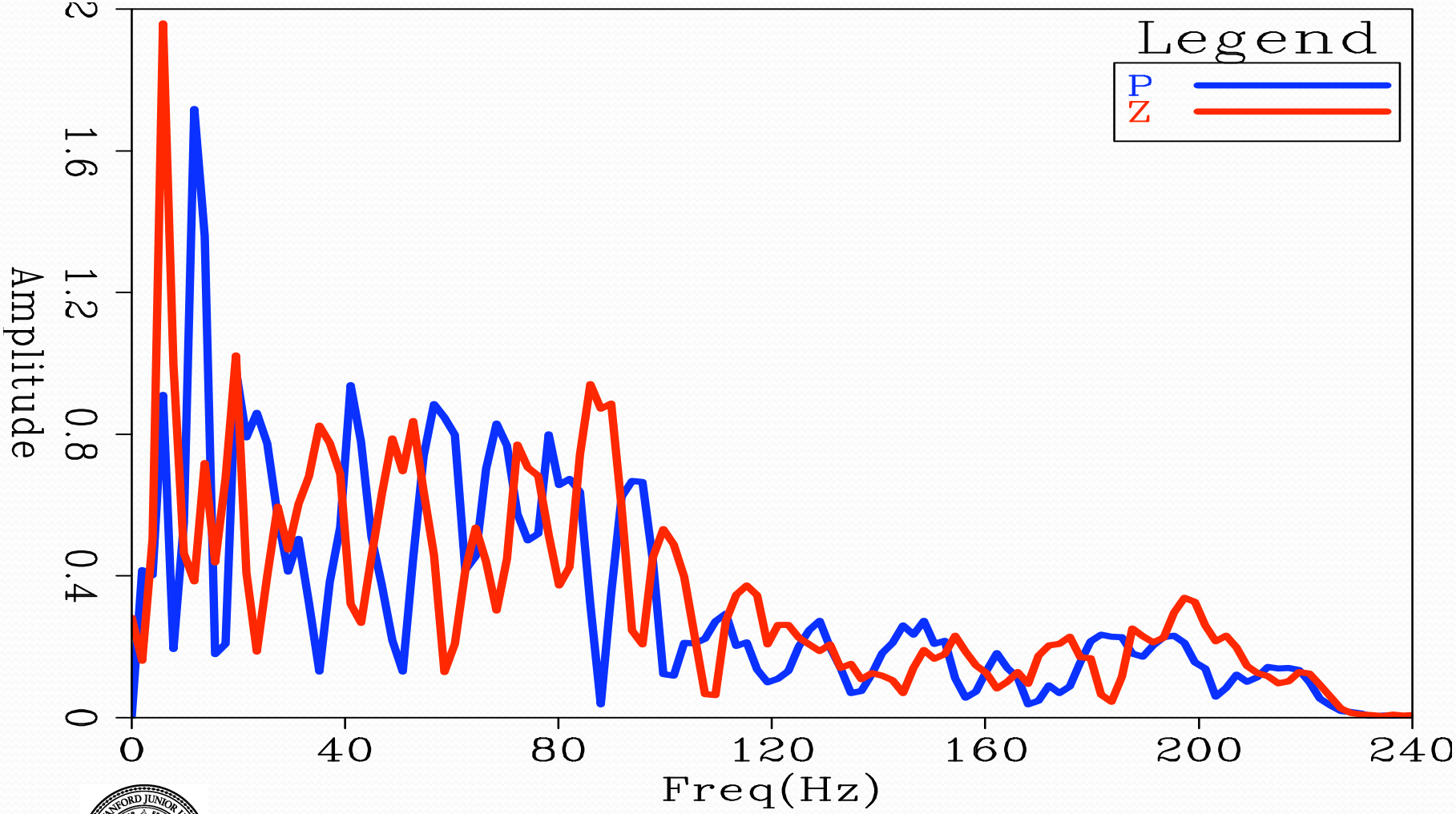


$$f_n(x) = \frac{nv}{\sqrt{(3D+d)^2+x^2} - \sqrt{(D-d)^2+x^2}}$$


P
0
50
100
150
200
250
Freq(Hz)
-4000
-2000
0
2000
4000
6000
8000
offset (m)


Notch frequency
0
50
100
150
200
250
Frequency (hz)
-6000
-4000
-2000
0
2000
4000
6000
offset (m)

Spectra at near zero offset



Procedures for Source wavelet extraction

✧ Source wavelet can be extracted from the direct arrival and direct arrival is down-going

✧ Time window around the direct arrival using HMO

✧ Perform Up-down separation using PZ summation

✧ Extract direct arrival from down-going wavefield

Hyperbolic Moveout

$$\Delta\tau = \sqrt{\tau_0^2 + \frac{x^2}{v^2}} - \tau_0$$

τ_0 is the zero-offset one-way traveltime

x is the offset

v is the water velocity

$\Delta\tau$ is the HMO time shift

Hyperbolic Moveout

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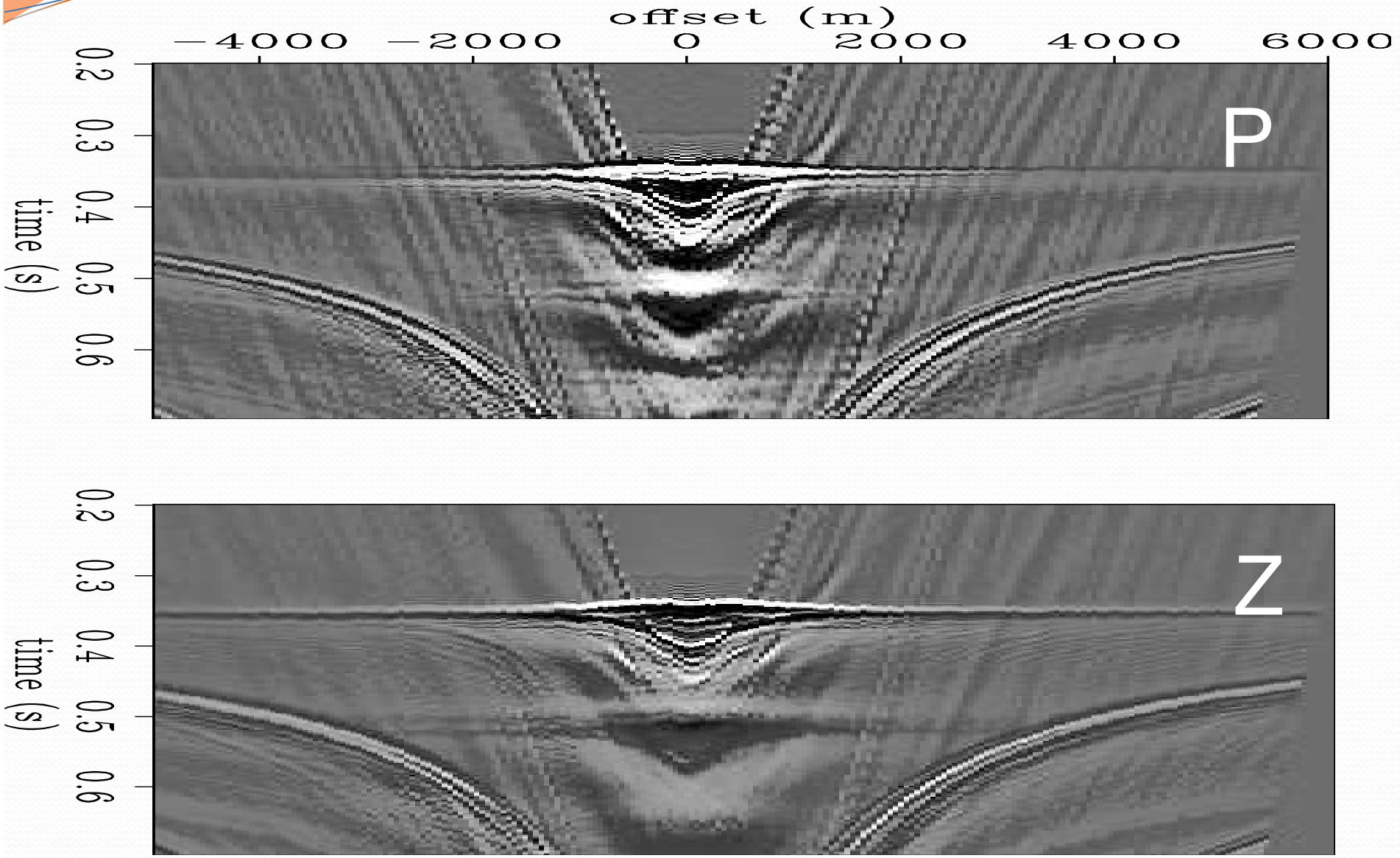
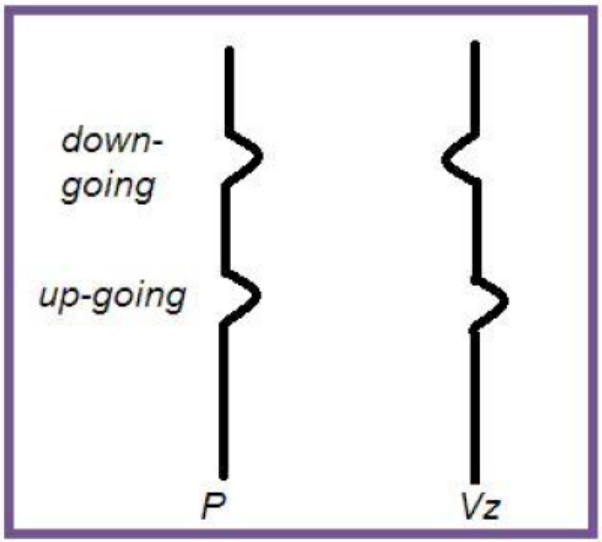
$\Delta\tau$ is the HMO time shift

HMO: Static shifts
NMO: Stretch

Hyperbolic Moveout



PZ summation

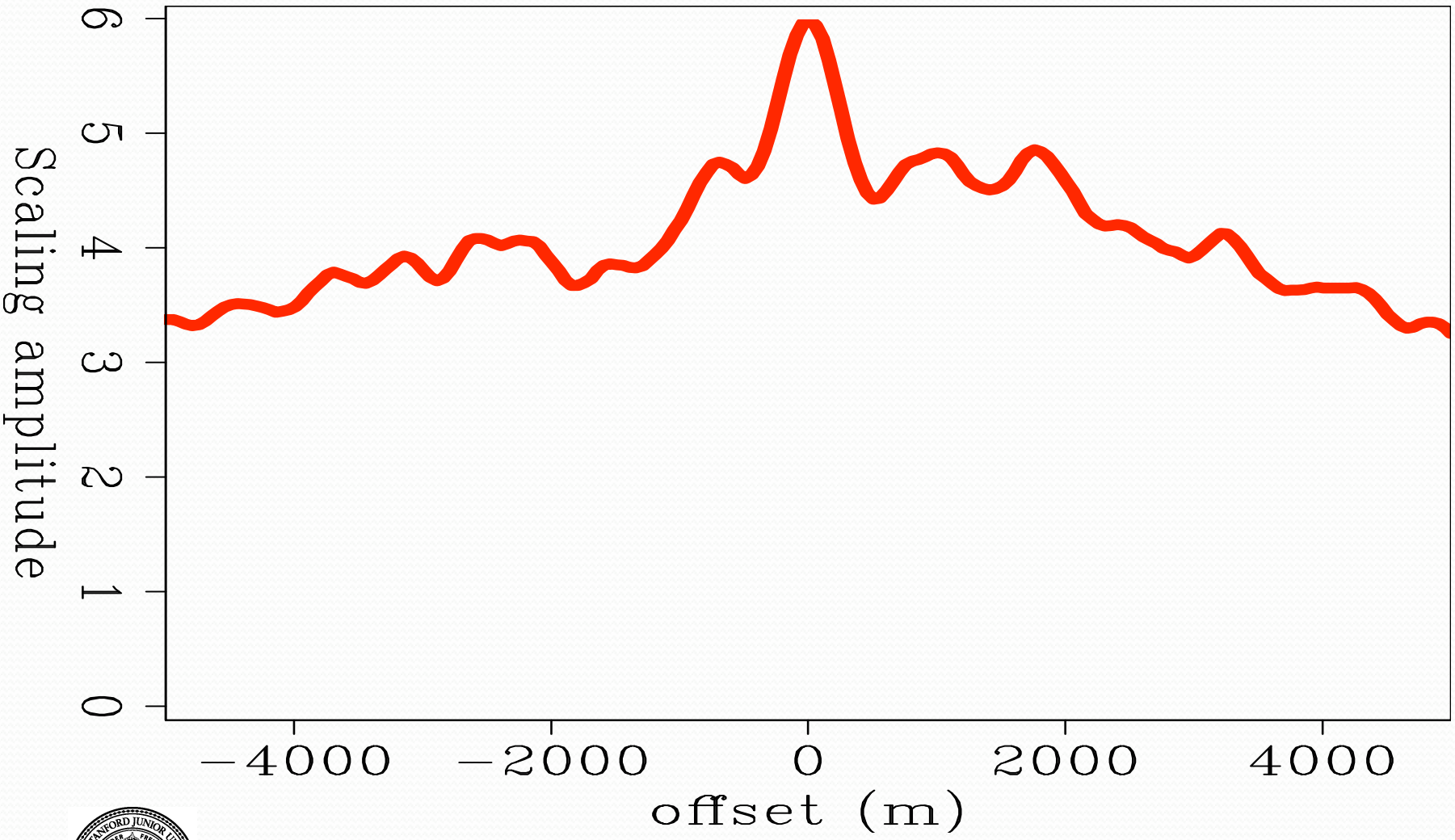


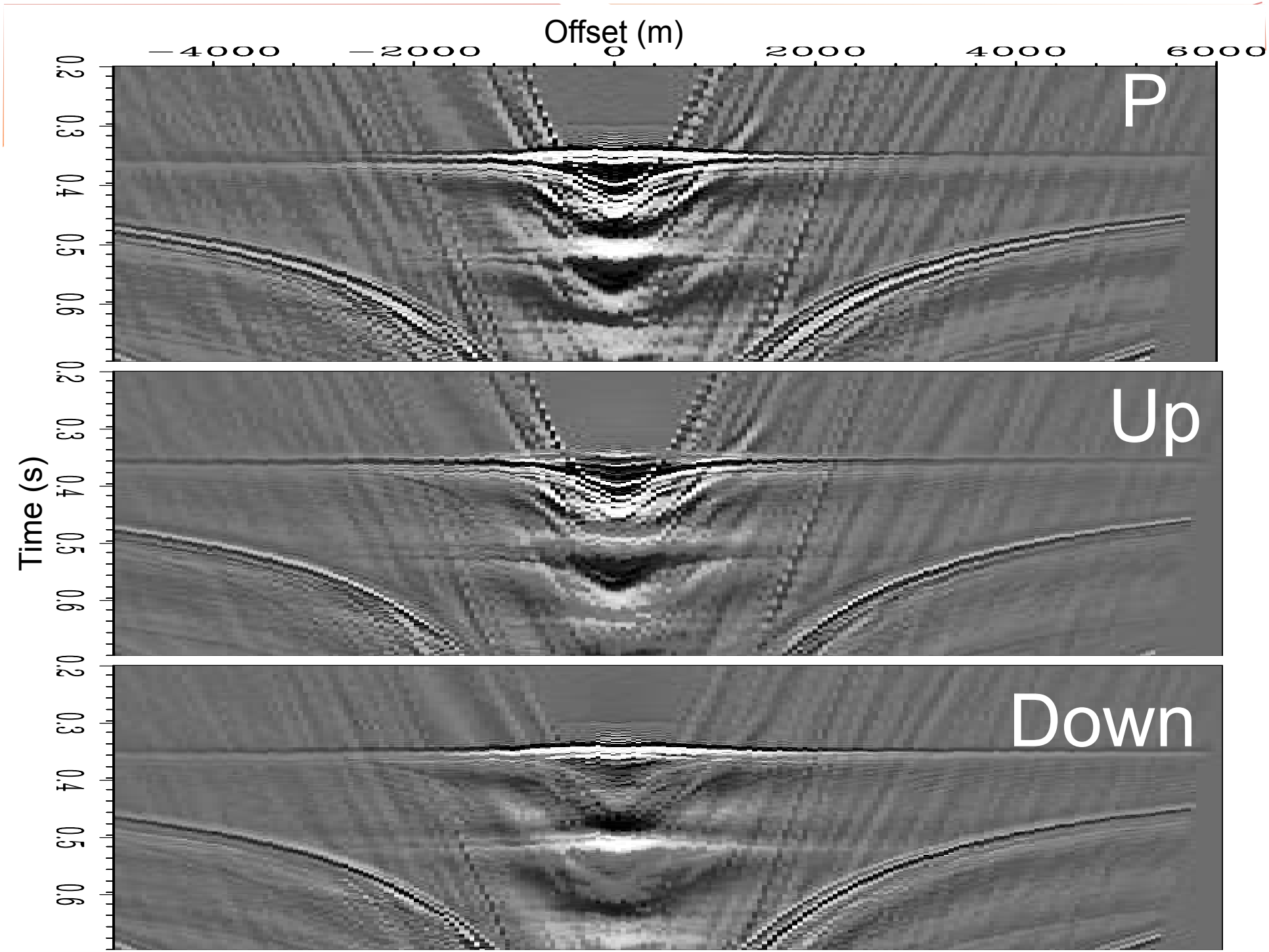
$$U(t,x) = \frac{1}{2}\left(P(t,x) + \text{scale}(x) Z(t,x)\right),$$

$$D(t,x) = \frac{1}{2}\left(P(t,x) - \text{scale}(x) Z(t,x)\right),$$

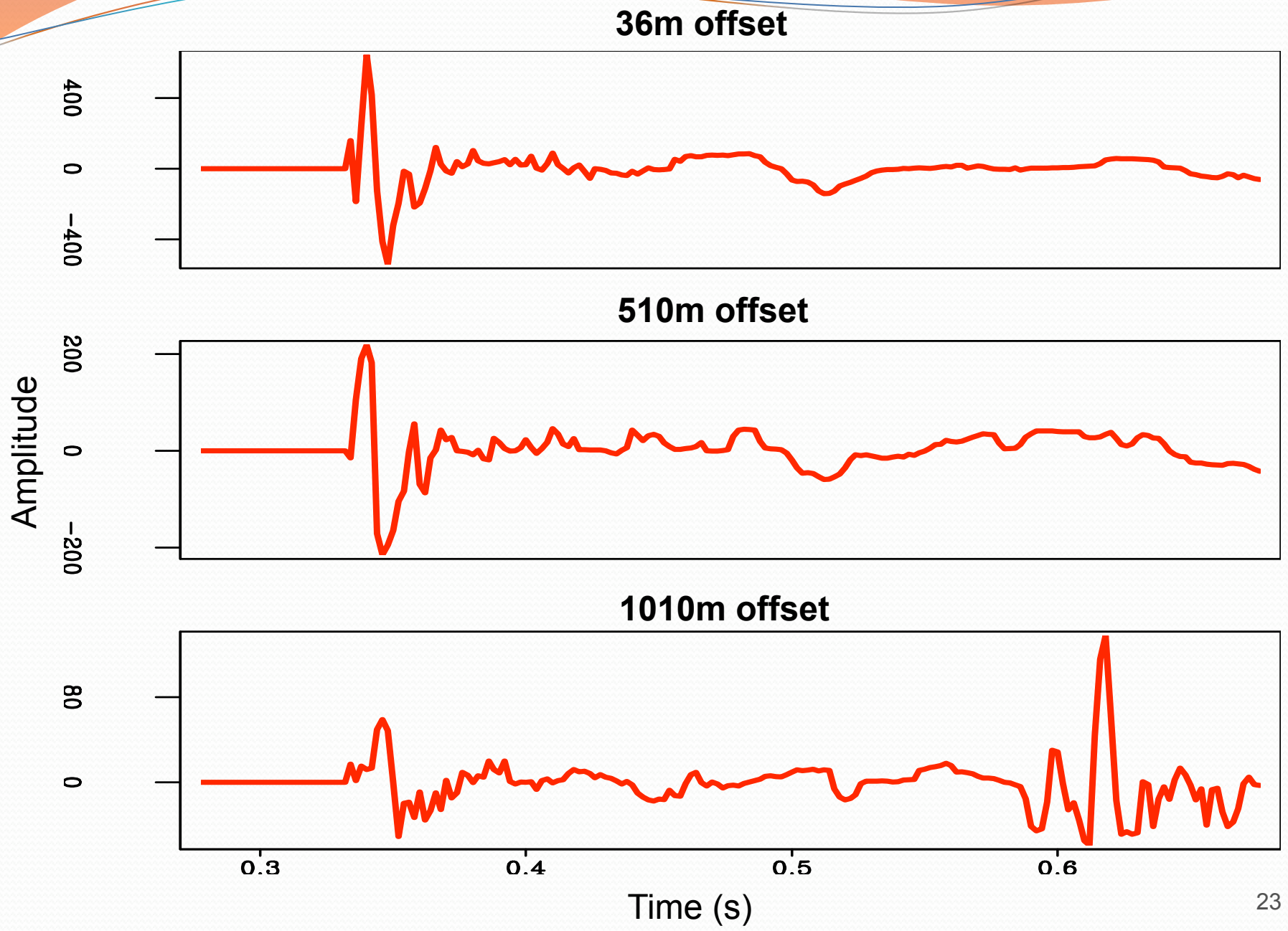
$$\text{scale}(x) = \frac{\sum_{t\in\Omega_t} \mid P(t,x) \mid}{\sum_{t\in\Omega_t} \mid Z(t,x) \mid},$$

Scaling factors for PZ summation

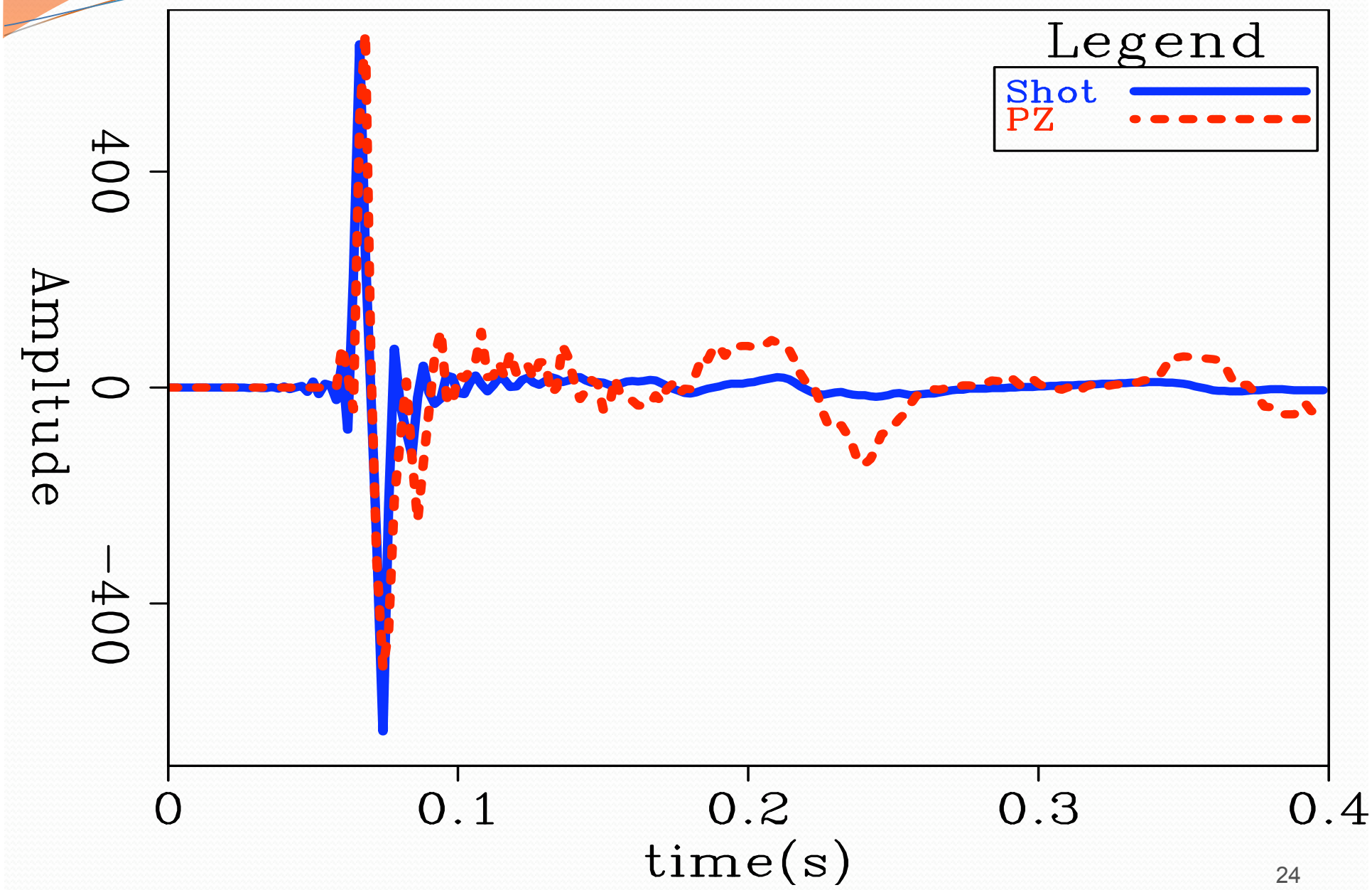



Offset (m)
−4000
−2000
0
2000
4000
6000
Time (s)
0.2
0.3
0.4
0.5
0.6
P
Up
Down

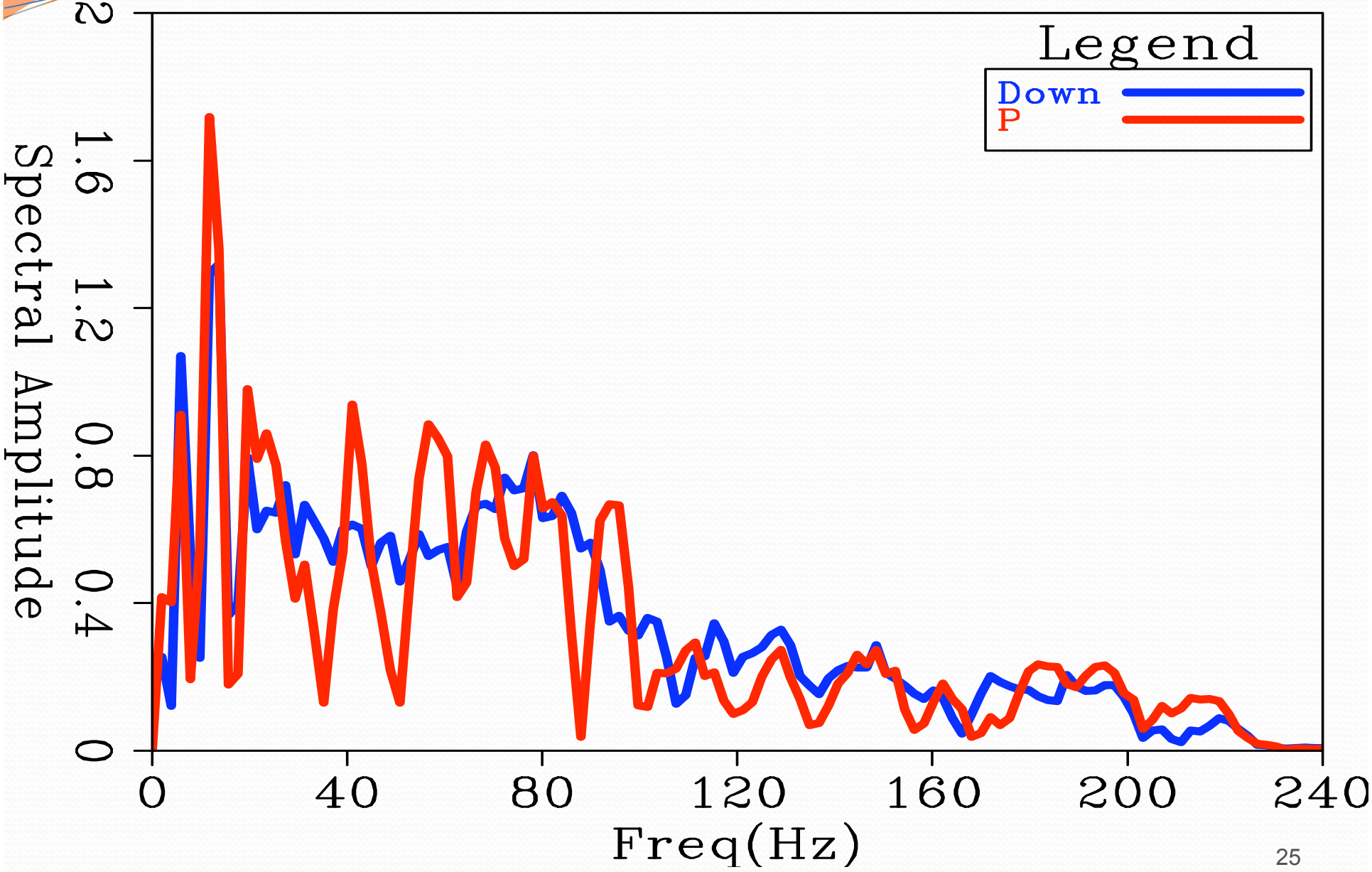
Source wavelet extracted



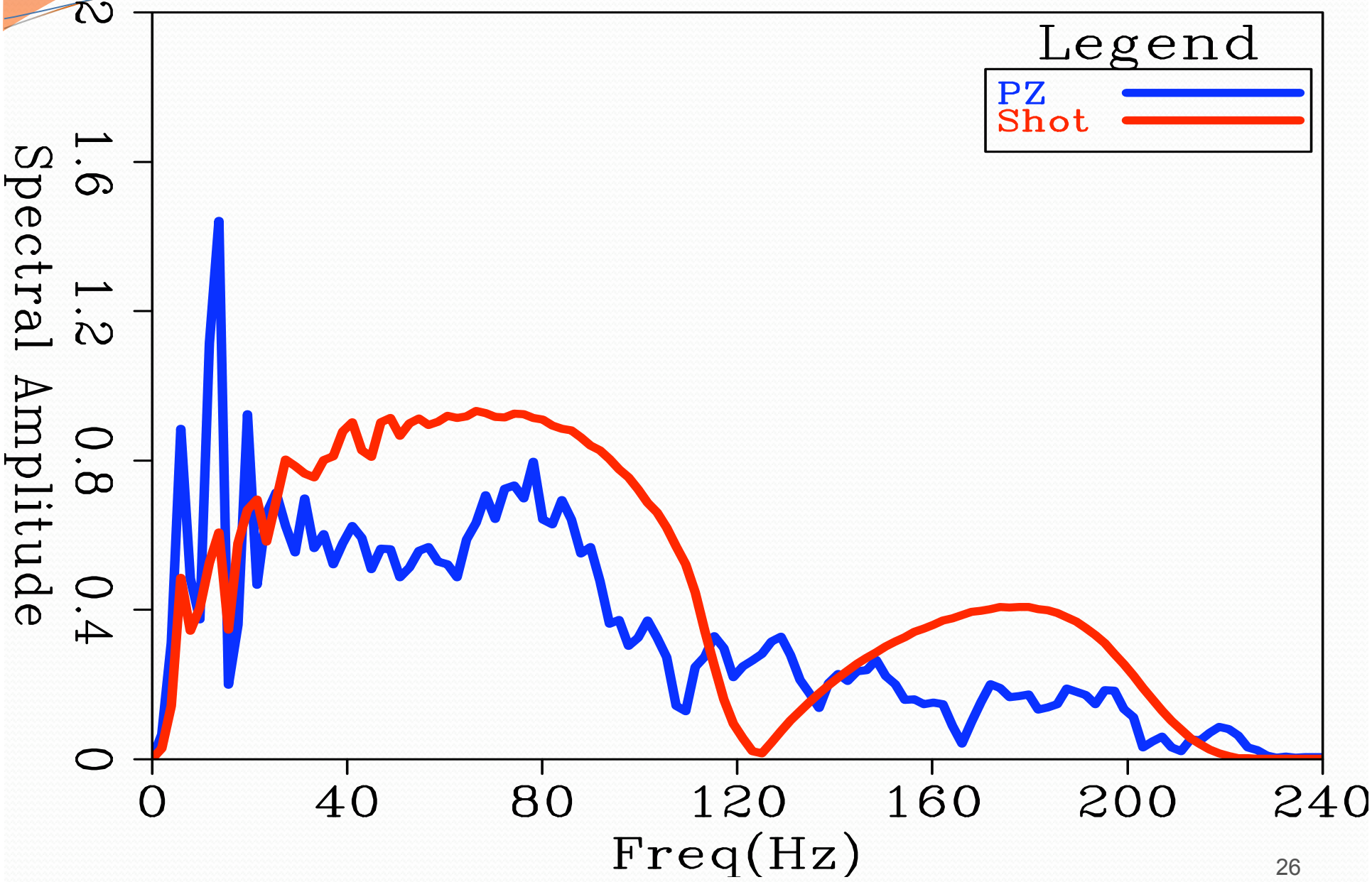
Shot wavelet: PZ summed vs. Shot array estimated



Spectra at 36m offset



Spectra: PZ summed vs Shot array estimated



Conclusion

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❖ PZ summation in the t-x domain are limited for large offset.

❖ Further improvement can be made with separation of Pressure and Shear component in Z recording.

Acknowledgement

- We thank Sea Bird for the release of this dataset.

- We thank the Sponsor of Stanford Exploration Project for funding this research.

- Help and support of senior students.