Ground Roll Attenuation of Seismic Data through Model-Based Inversion: A Synthetic study

OSPA

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12th December 2022
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GROUND ROLL

- *Low frequency*
- *High amplitude*
- *Low velocities*

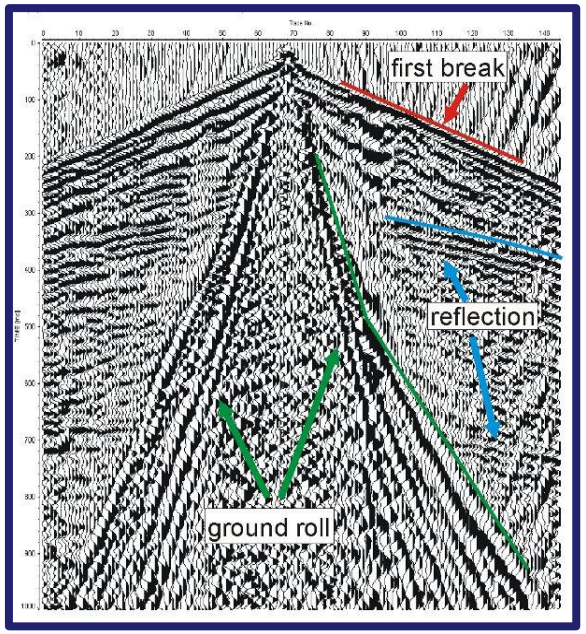


Figure1. Different events observed in seismic data (http://www.geofact.de/?page_id=1809&language=en)

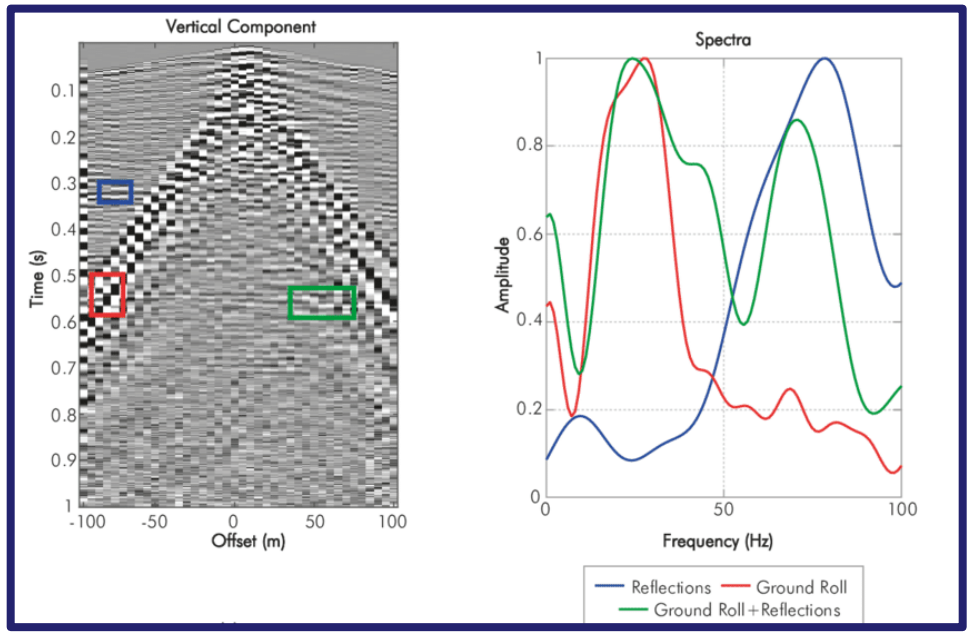


Image Courtesy: Galvis et al. (2016)

GROUND ROLL ATTENUATION

Modeling

Thickness
Density
Vp
Vs
Qp
Qs

Synthetic Ground Roll

Adaptive Subtraction

Inversion

Genetic Algorithm

Optimal Earth model (GR)

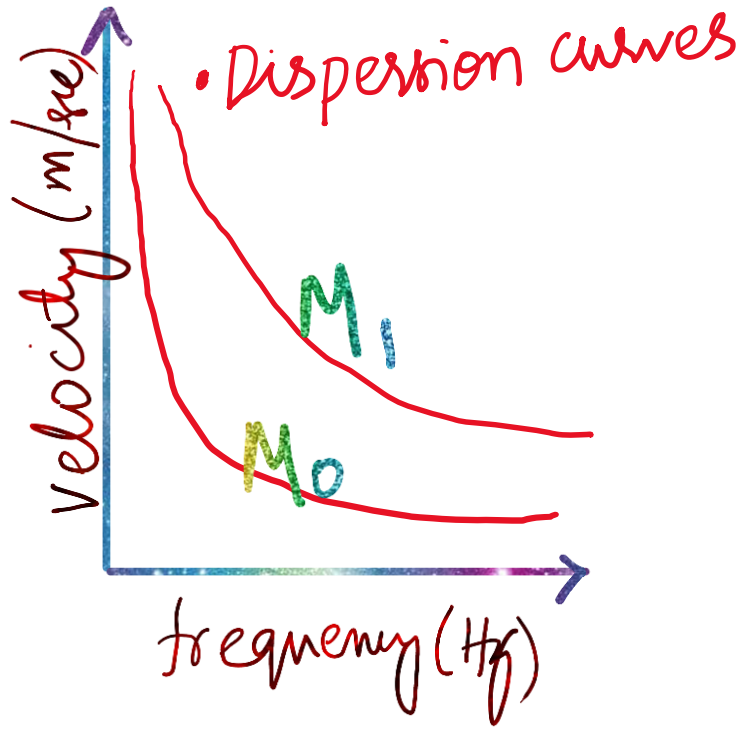
GROUND ROLL ATTENUATION

- Model ⟶ Synthetic Ground Roll
- Dispersion spectrum through Linear Radon Transformation

$$u(p,\tau) = \int_{-\infty}^{+\infty} d(x, t = \tau + px)dx$$

$d(x,t)$ is the Shot Gather

$u(p,\tau)$ is the slant-stack transform with horizontal slowness (or ray parameter) p and intercept time τ.



Mis-fit

$$J(m) = \sqrt{\sum_{i=1}^{n_f}\sum_{j=1}^{n_v}\frac{(s_{ij} - o_{ij})^2}{n_f n_v}}$$

- S is the dispersion spectrum of the synthetic data generated from the model
- O is the dispersion spectrum of shot gather
- n_f, n_v are the number of sampling points along the frequency and Phase Velocity axis

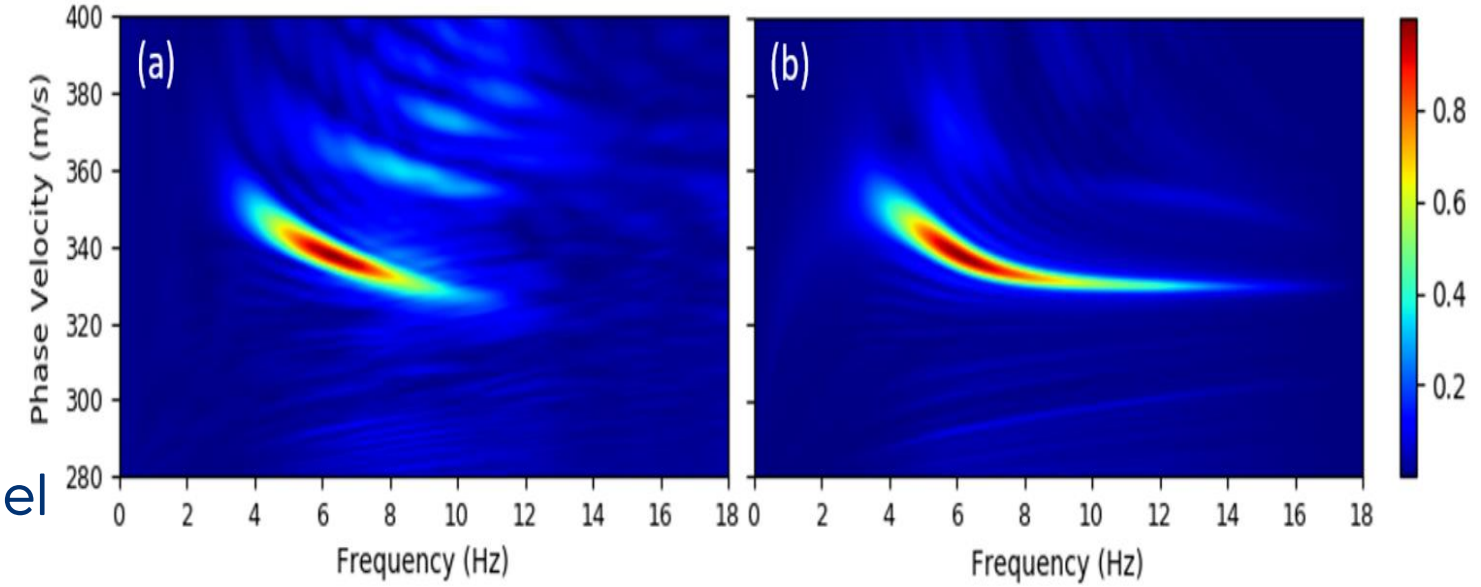
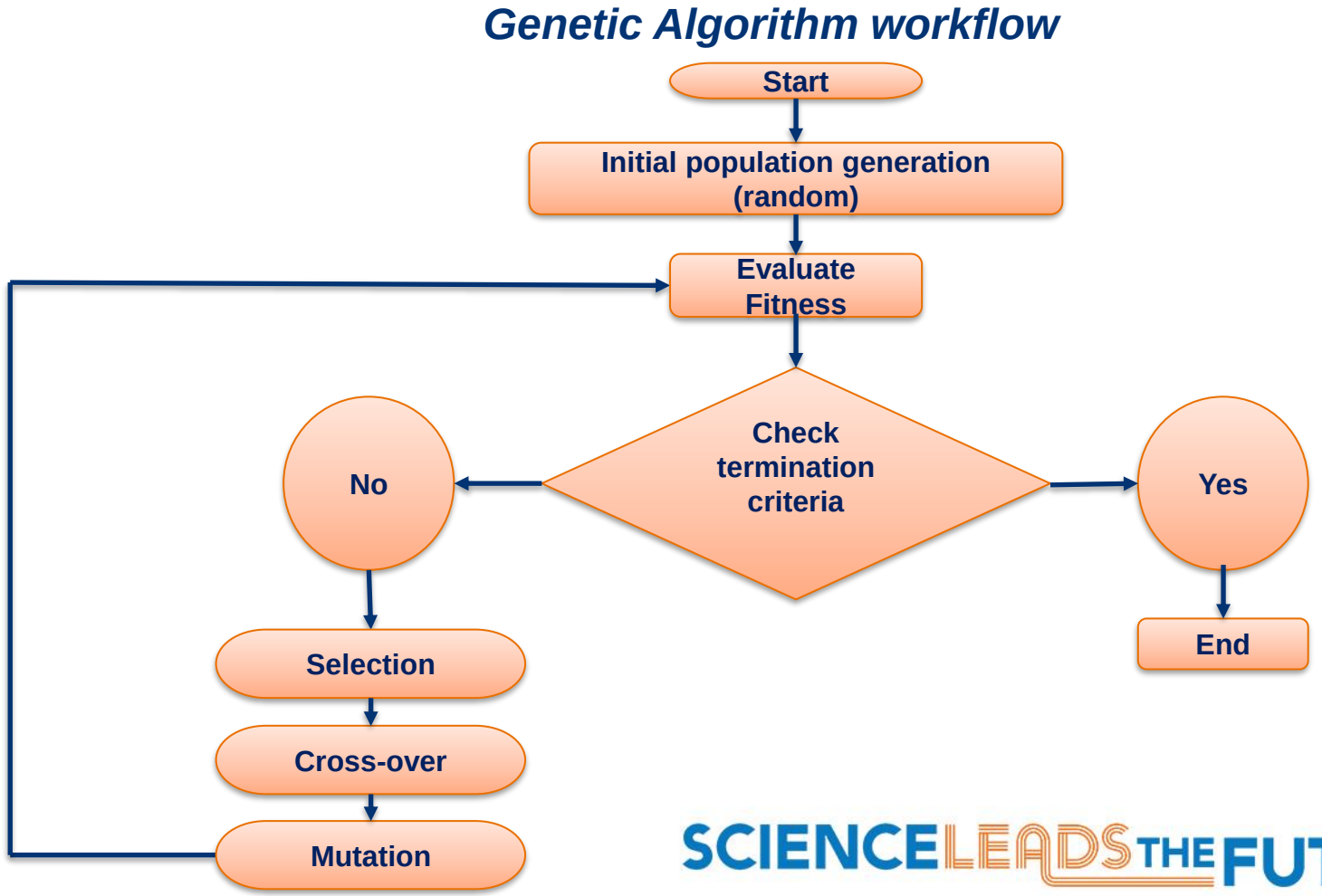


Figure 2.0 Dispersion spectra obtained from seismic(a) and synthetic (b) data. Image Courtesy: Jianyong Bai and Orhan Yilmaz (2020, SEG International Exposition and 90th Annual Meeting)

INVERSION: optimization problem

- Minimize J(m)
- Non-Linear Problem
  Multiple Local Minima
- Genetic Algorithm
- Linearized optimization
- Multi-Scale technique



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OZ-25 Dataset: A case study

Typical dataset for GR attenuation study:

1. Large Amount of GR
2. Primary reflections are covered by coherent GR
3. Variable amplitude of reflections in the whole gather

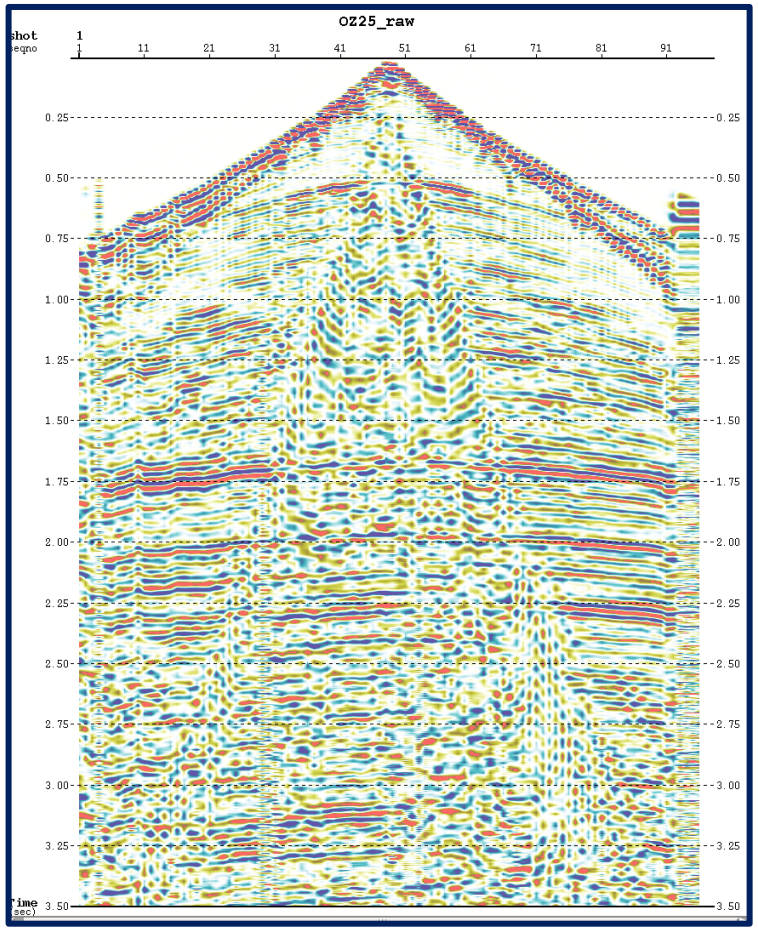

Figure 3.0:Raw OZ-25 field data (SEG Open data)

OZ-25 Dataset: A case study

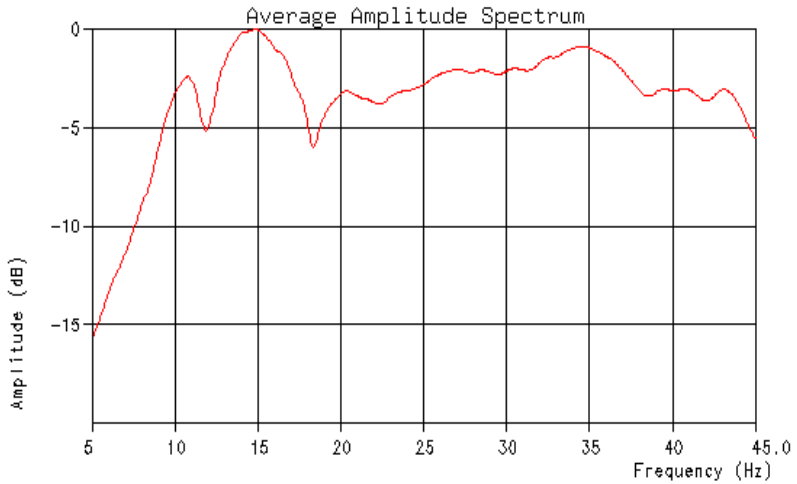

Fig. 4.0: Plot suggesting low-frequency dominancy(GR)

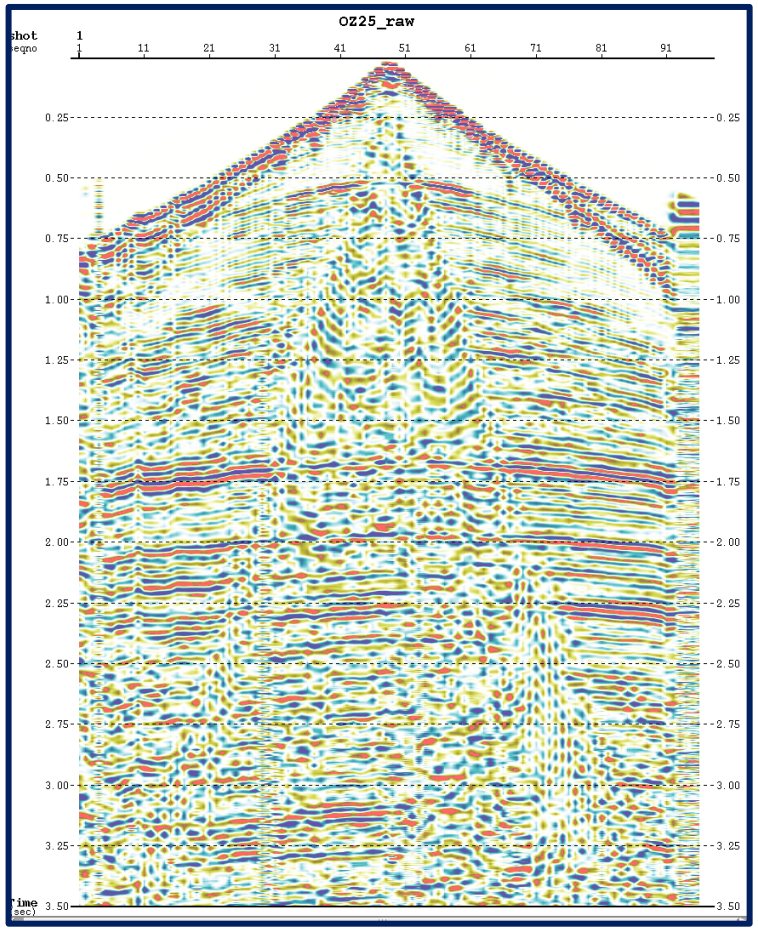

Figure 3.0:Raw OZ-25 field data (SEG Open data)

Model:
Fmax: 15 Hz

Vmin=10m/s , Vmax =200m/s
Hmin =3m, Hmax = 1000m

Vmin=100m/s , Vmax =250m/s
Hmin =3m, Hmax = 200m

Vmin=100m/s , Vmax =300m/s
Hmin =3m, Hmax = infinite

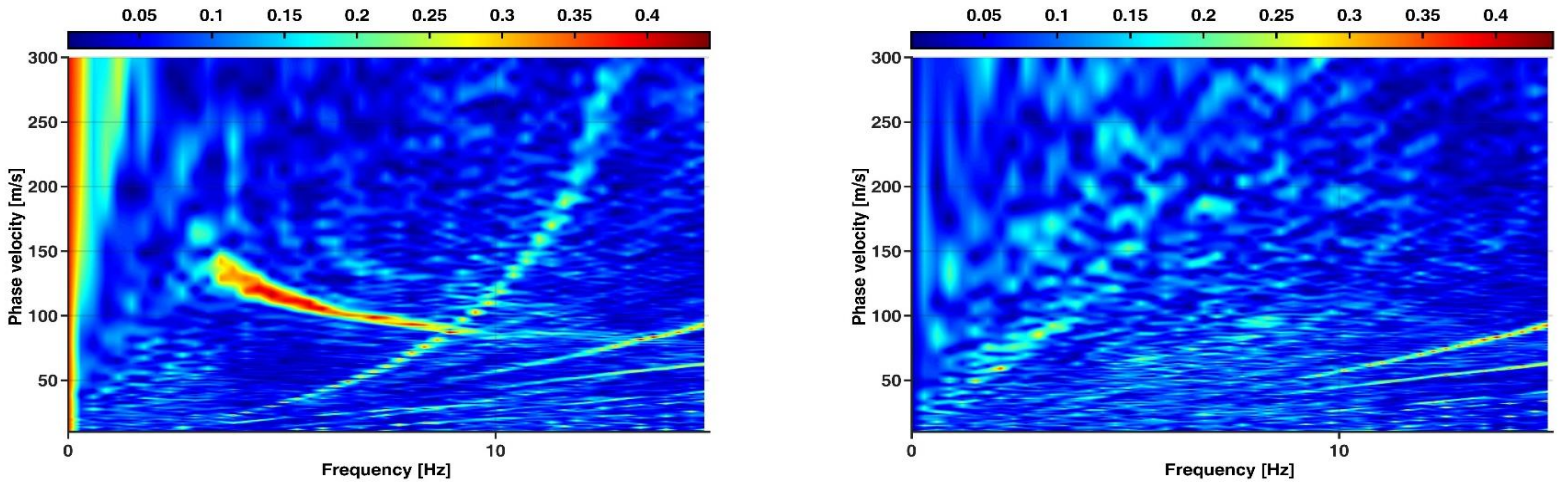

Fig. 5.0: *Dispersion Spectra of the raw Shot gather(left), Dispersion spectra after adaptive subtraction (right)*

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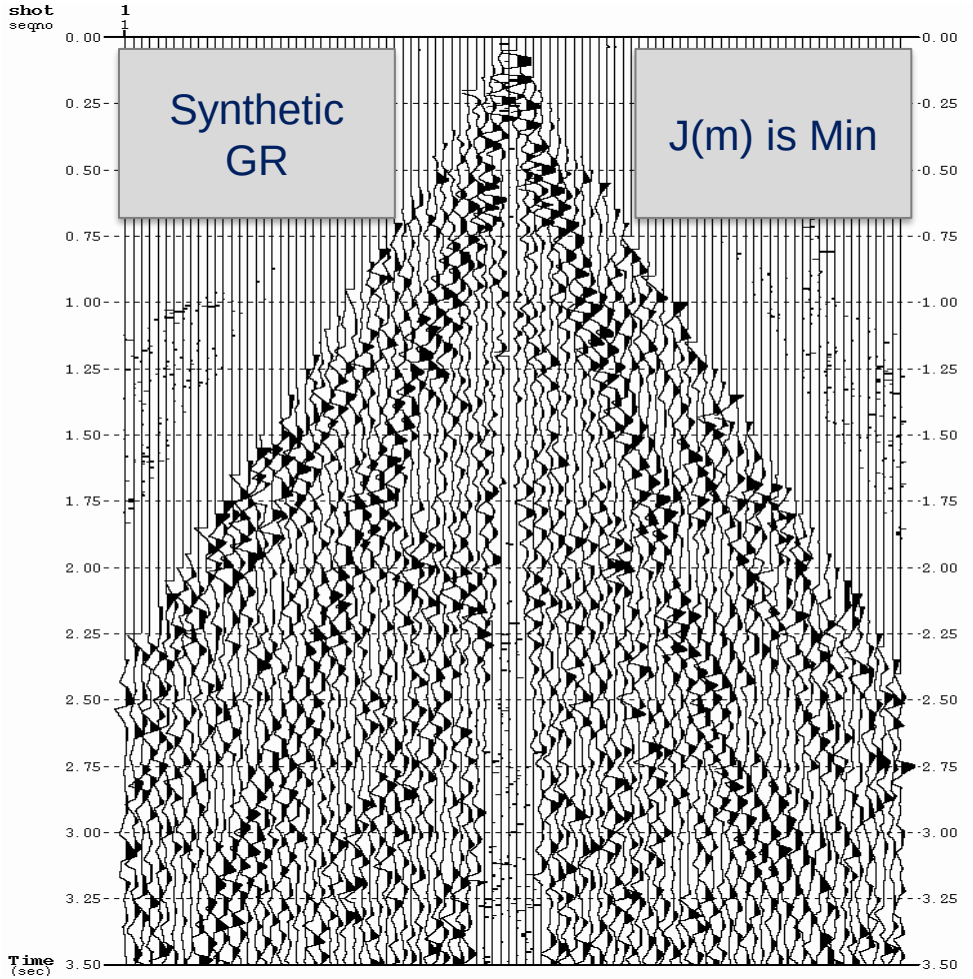


Raw Data

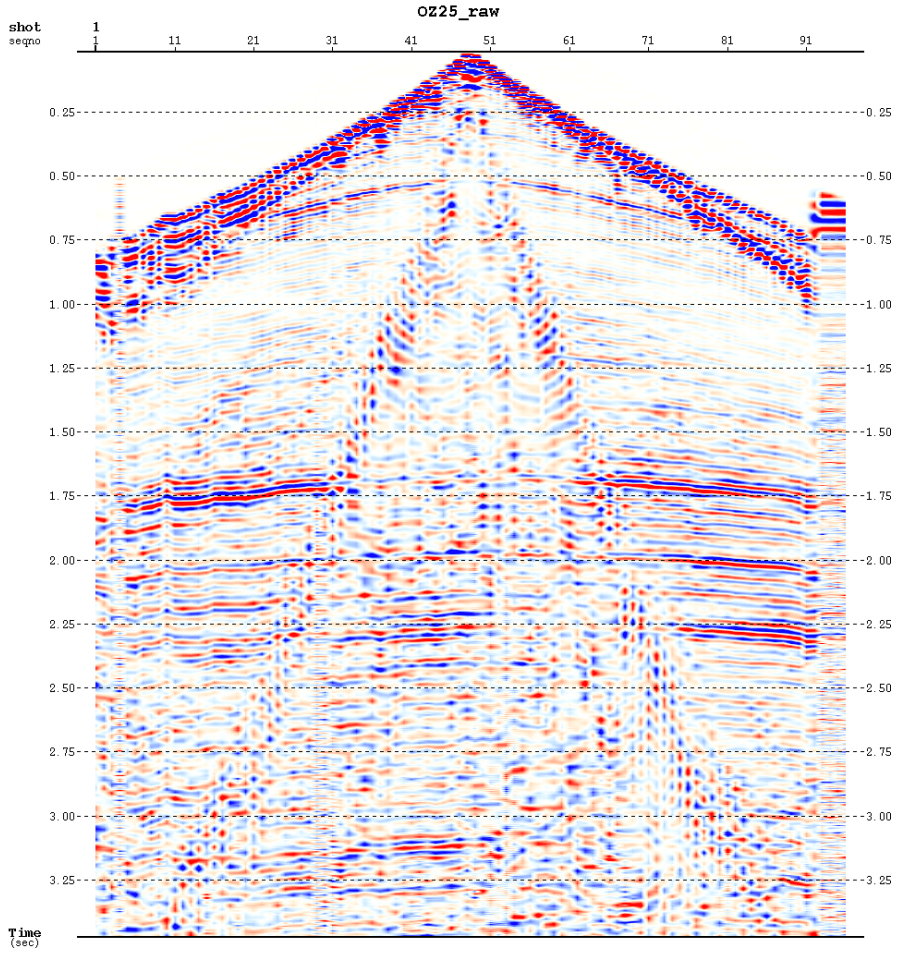
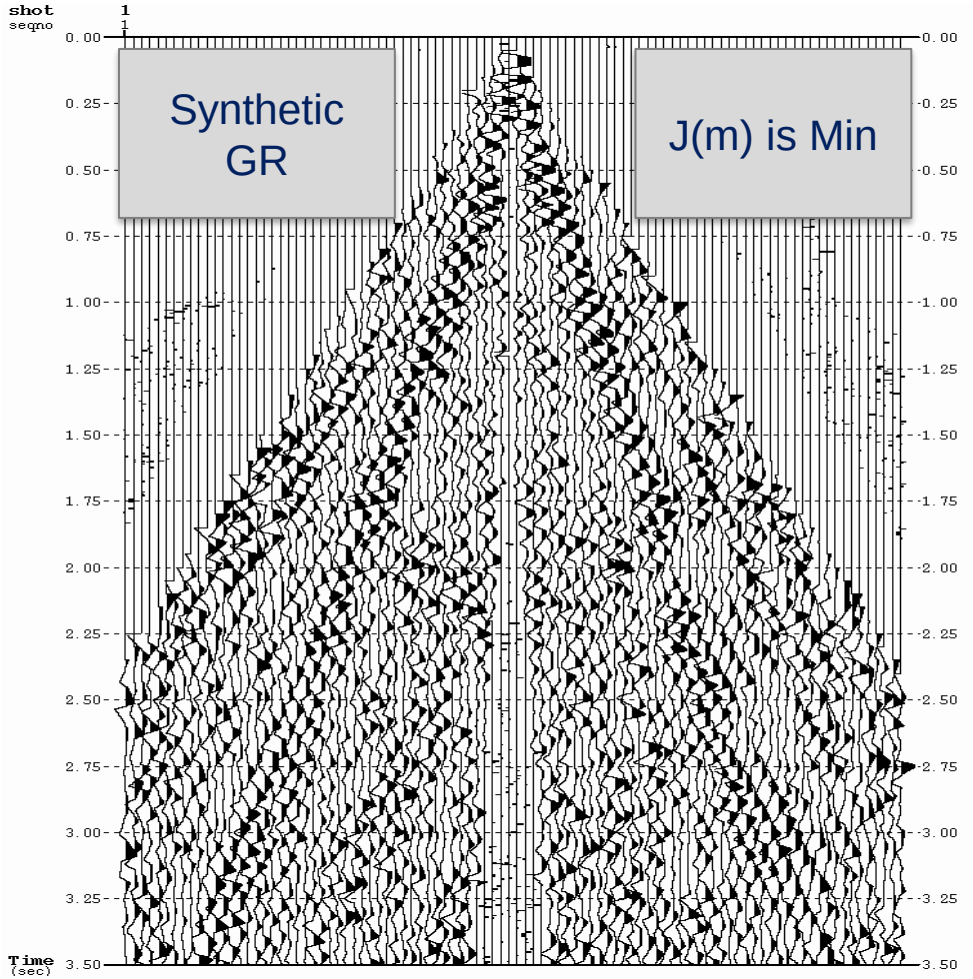


Figure 6.0: Synthetic GR generated from optimized Earth Model



GR Attenuated Data

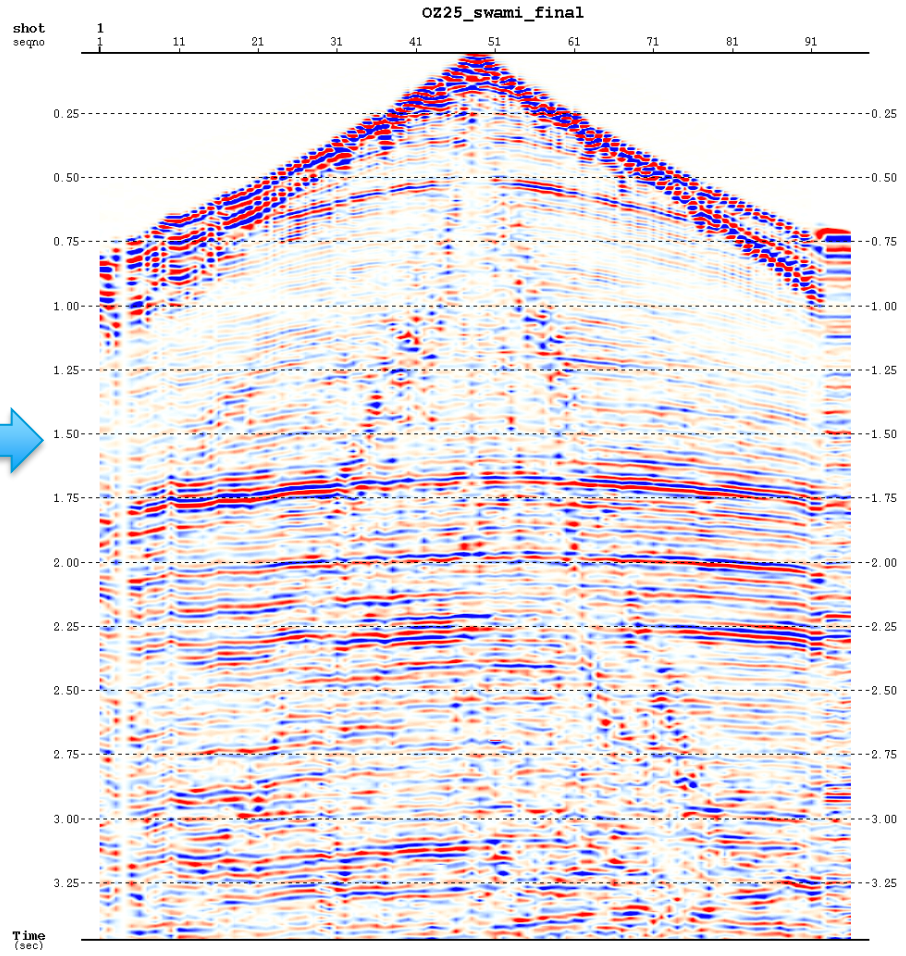
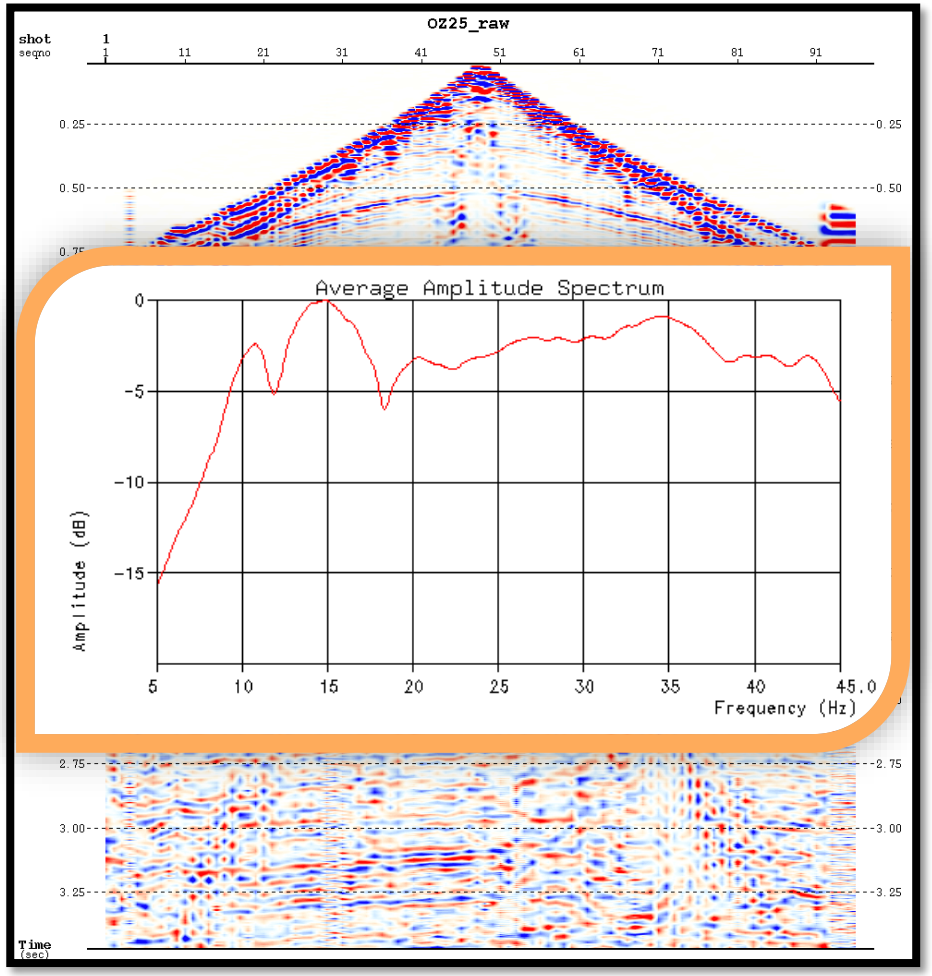
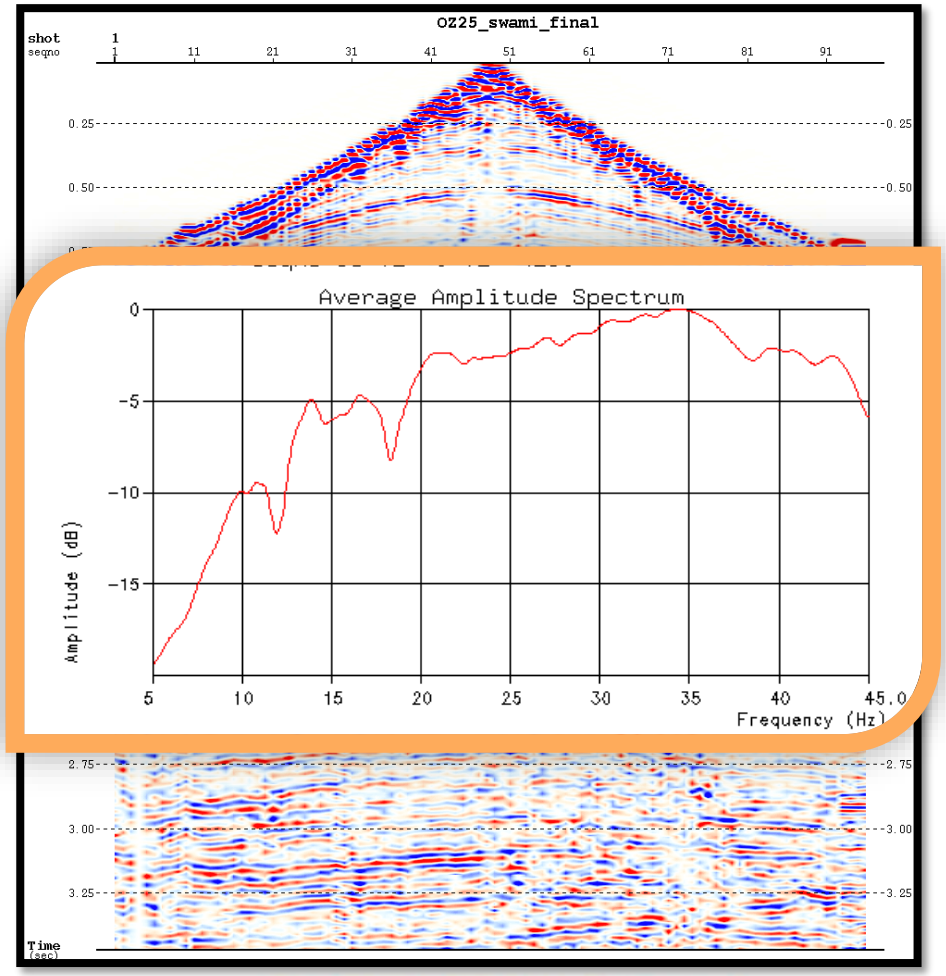
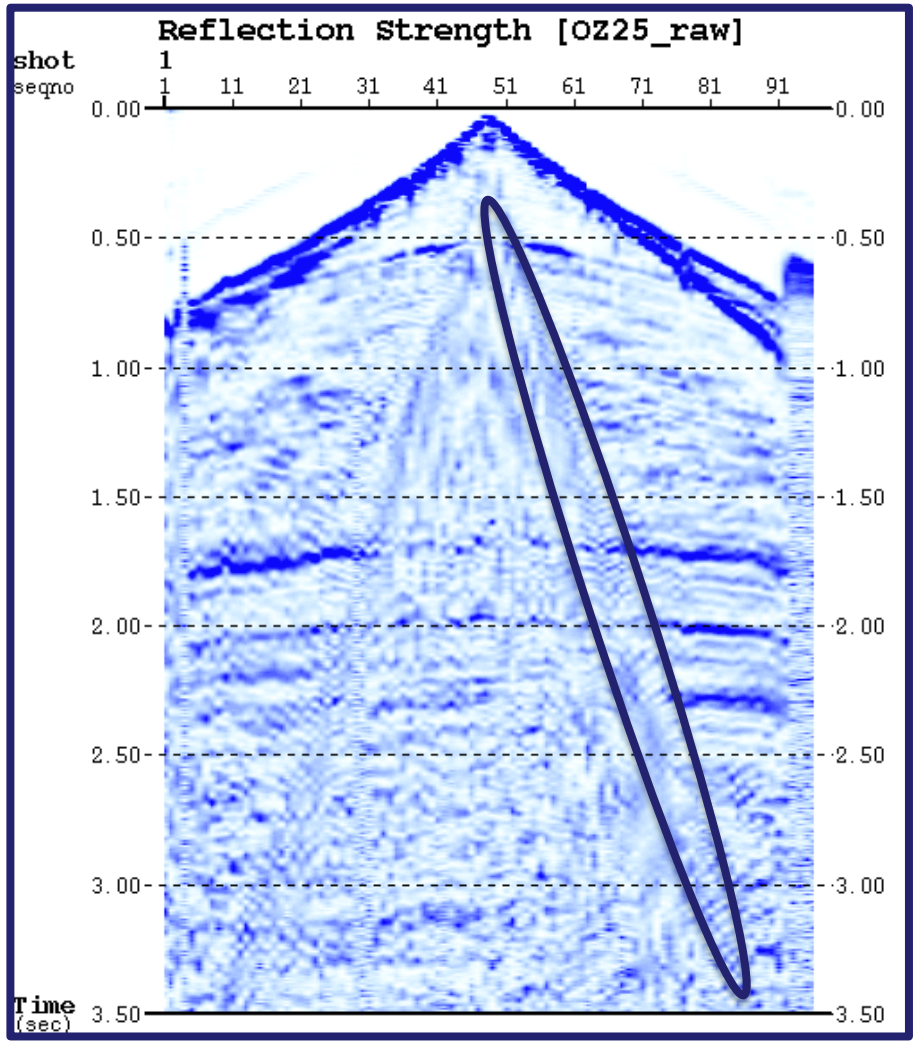
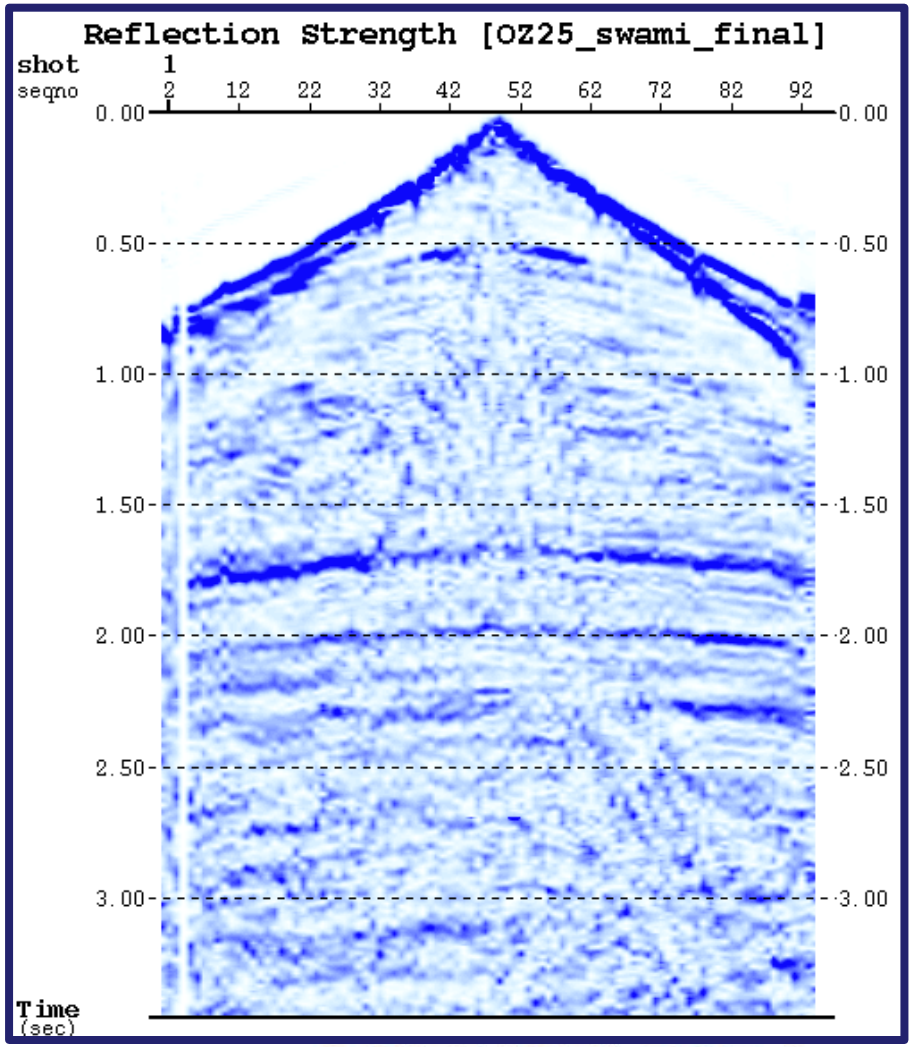


Figure 6.0: Synthetic GR generated from optimized Earth Model


OZ25_raw
shot
seqno
Average Amplitude Spectrum
Amplitude (dB)
Frequency (Hz)
Time
(sec)


OZ25_swami_final
shot
seqno
Average Amplitude Spectrum
Amplitude (dB)
Frequency (Hz)
Time
(sec)


Reflection Strength [OZ25_raw]
shot
seqno
1
1 11 21 31 41 51 61 71 81 91
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Time
(sec)


Reflection Strength [OZ25_swami_final]
shot
seqno
1
2 12 22 32 42 52 62 72 82 92
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Time
(sec)

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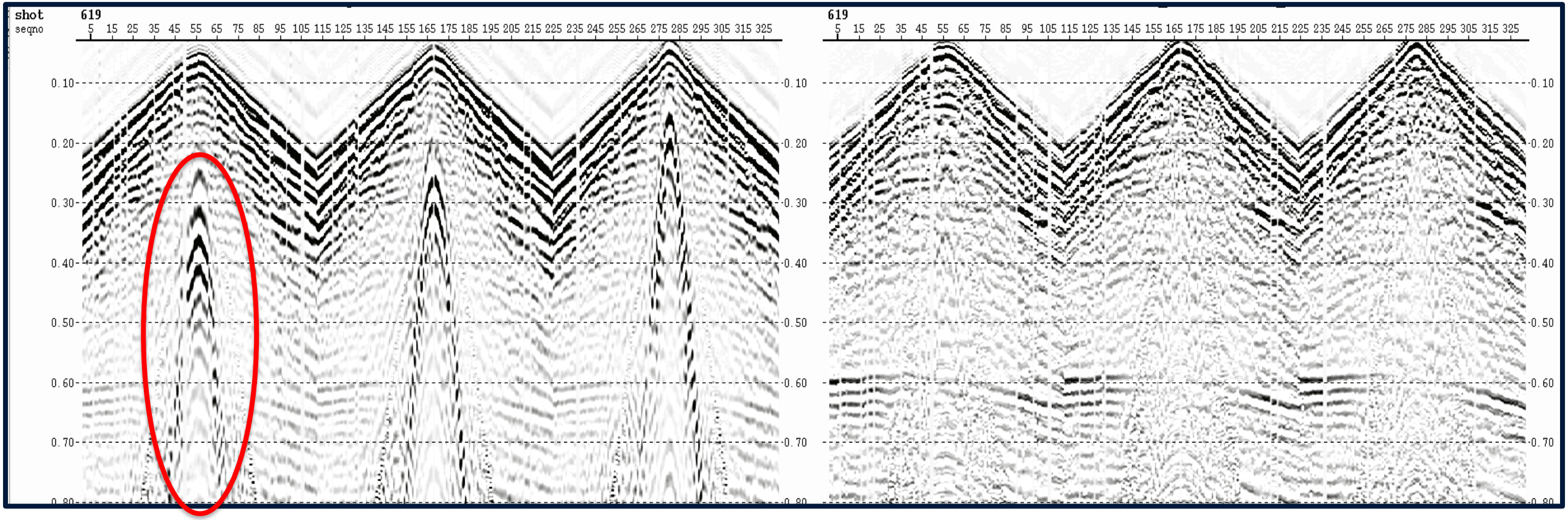
3D shot gather of an Indian coal field



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