Processing of a Multicomponent Seismic Survey from West-Central Alberta

Winter 2019 Tech-Talk

Hussain Aldhaw
Supervisor: Dr. Don Lawton

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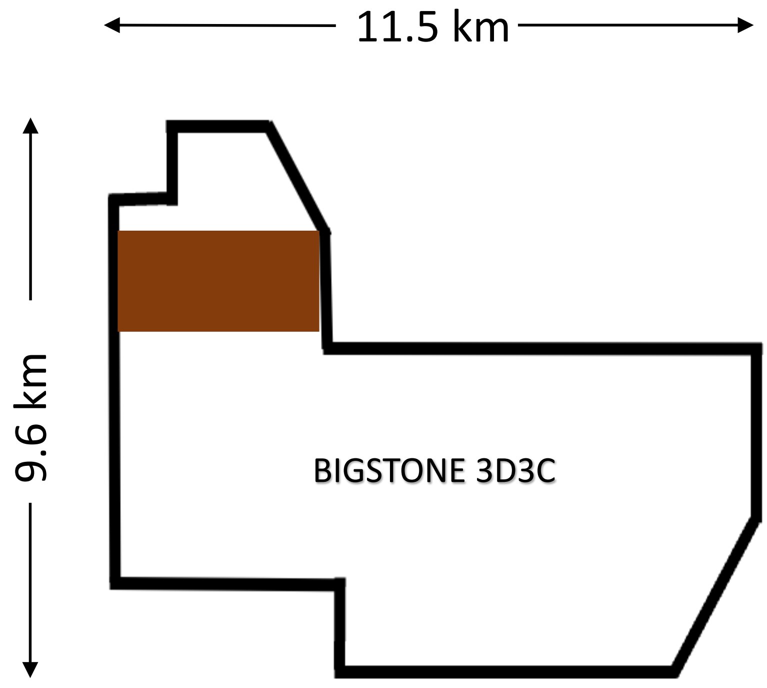
Goals

- Process PP and PS data from a portion of the Bigstone 3C3D seismic dataset.
- Register the PP and PS processed volumes through PSDM.
- Improve the S-wave velocities by looking closely at the pre-stack shallow data as the S-wave shallow data usually lose their characteristics after application of receiver statics.
- Test optimum binning of the PS data for improved PS velocity analysis.
- Couple improved velocity analysis with microseismic focal depth investigations.

Outline

- Introduction
- Processing Workflow
- Processing Steps
- Future Work

Introduction - Project Location Map



Project Map (Schematic)

- **The total area = ~100 sq.km.**
- **The area of the segmented data = ~44 sq.km**

Introduction - Acquisition Parameters

General Parameters

Survey Type	Orthogonal
Surface Area	~ 44 Sq.Km
Source Type	Dynamite
Widest Survey E-W	~ 8 Km
Widest Survey N-S	~ 5.5 Km

Instrumentation Parameters

Sample Rate	1 ms
Record Length	5 s
Low Cut Filter	3 Hz
High Cut Filter	400 Hz
Geophone Type	Accelerometer

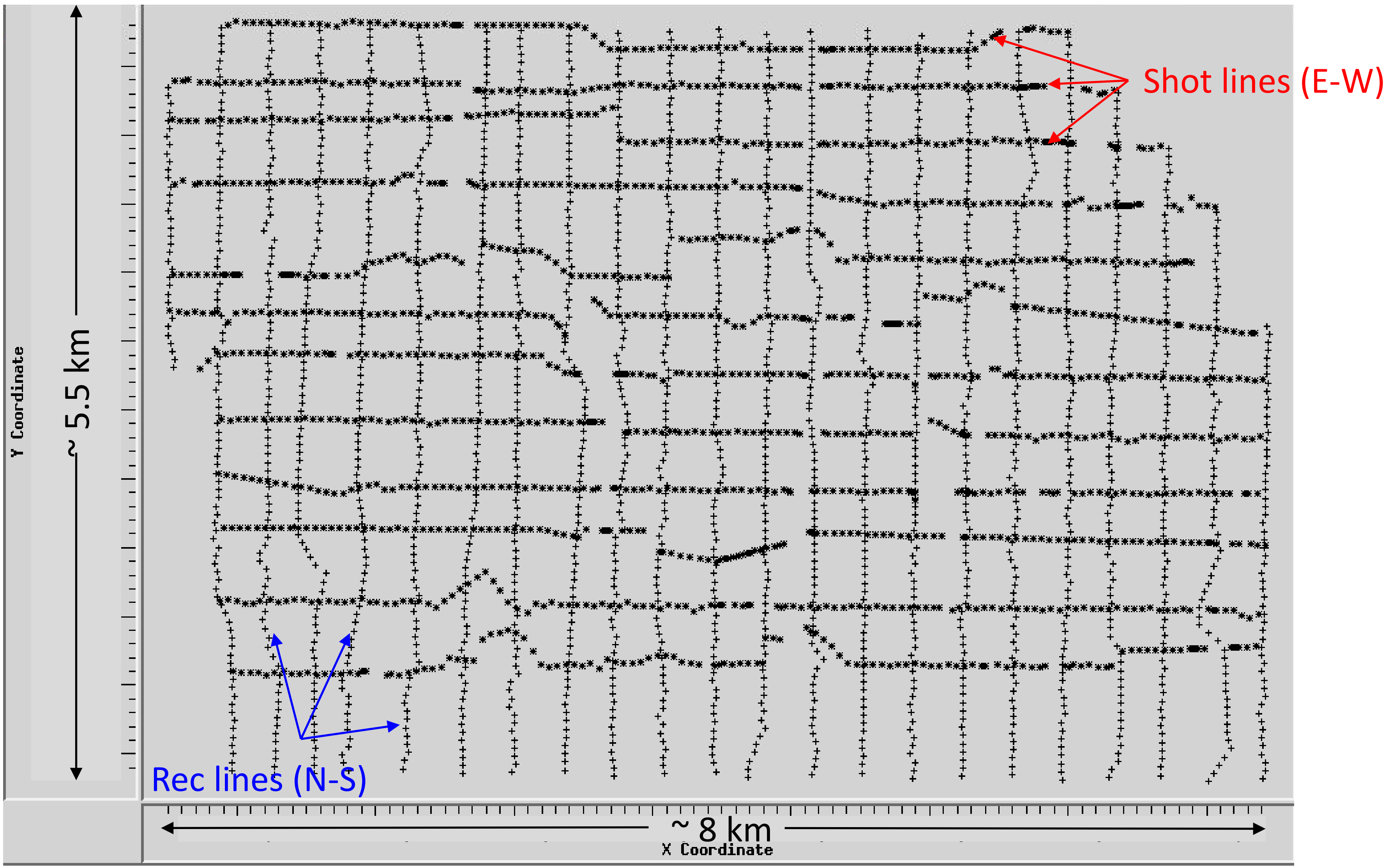
Receiver Parameters

Direction	N-S
Group Interval	60 m
Receiver Line Interval	360 m
Number of Receiver Lines	23

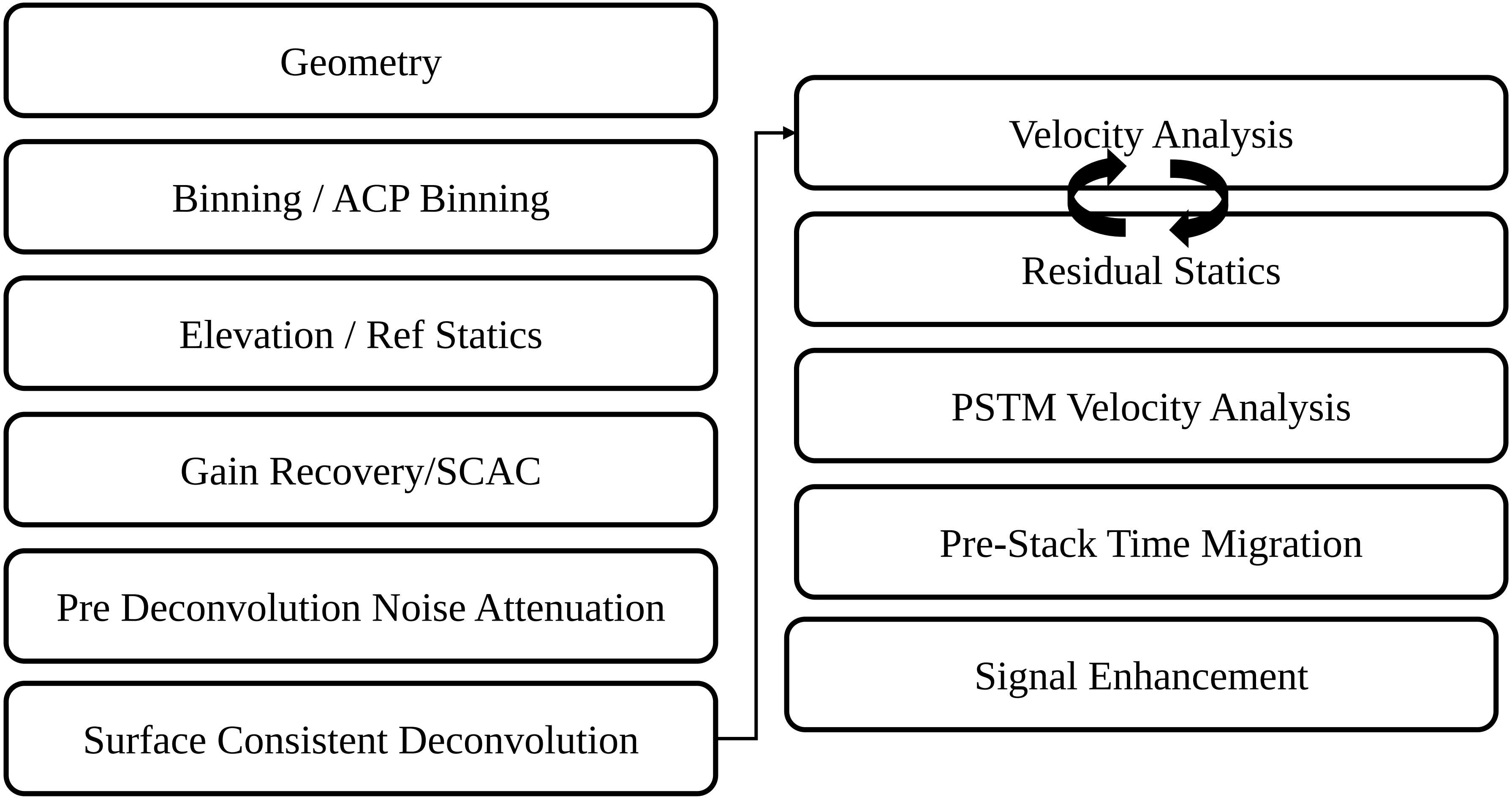
Source Parameters

Direction	E-W
Source Interval	60 m
Source Line Interval	420 m
Number of Source Lines	12
Bin Size	30m x 30m

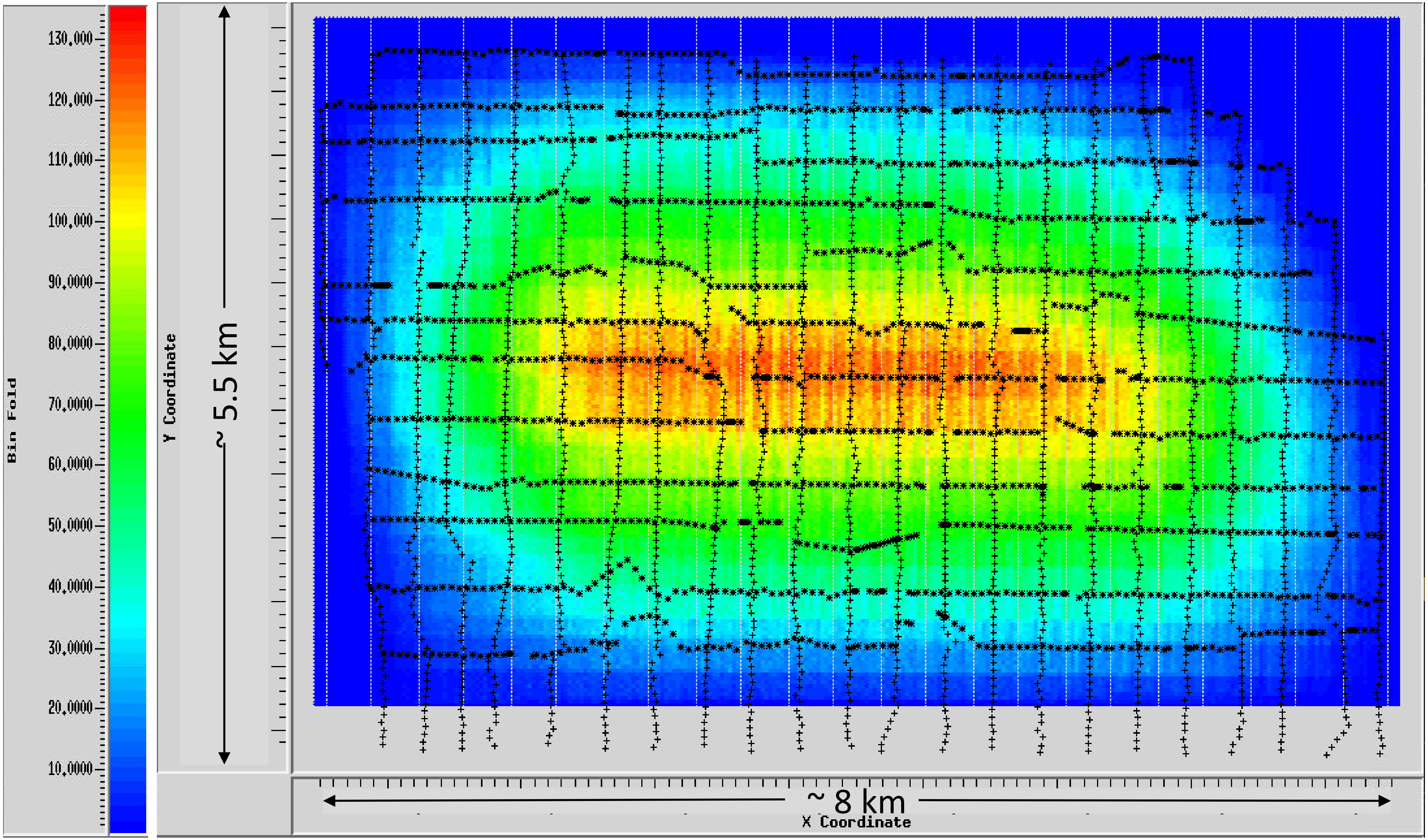
Processing Steps - Geometry



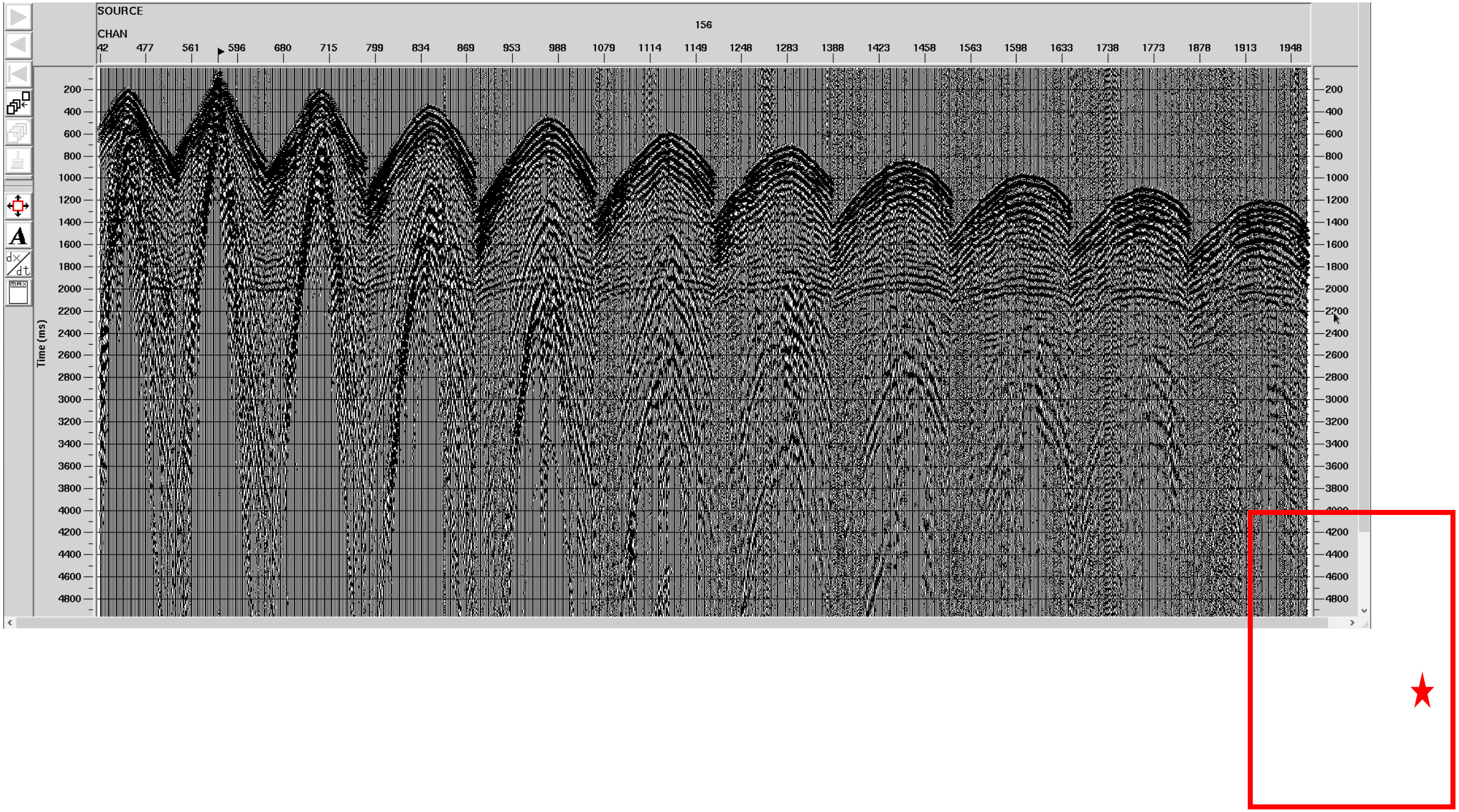
Processing Workflow



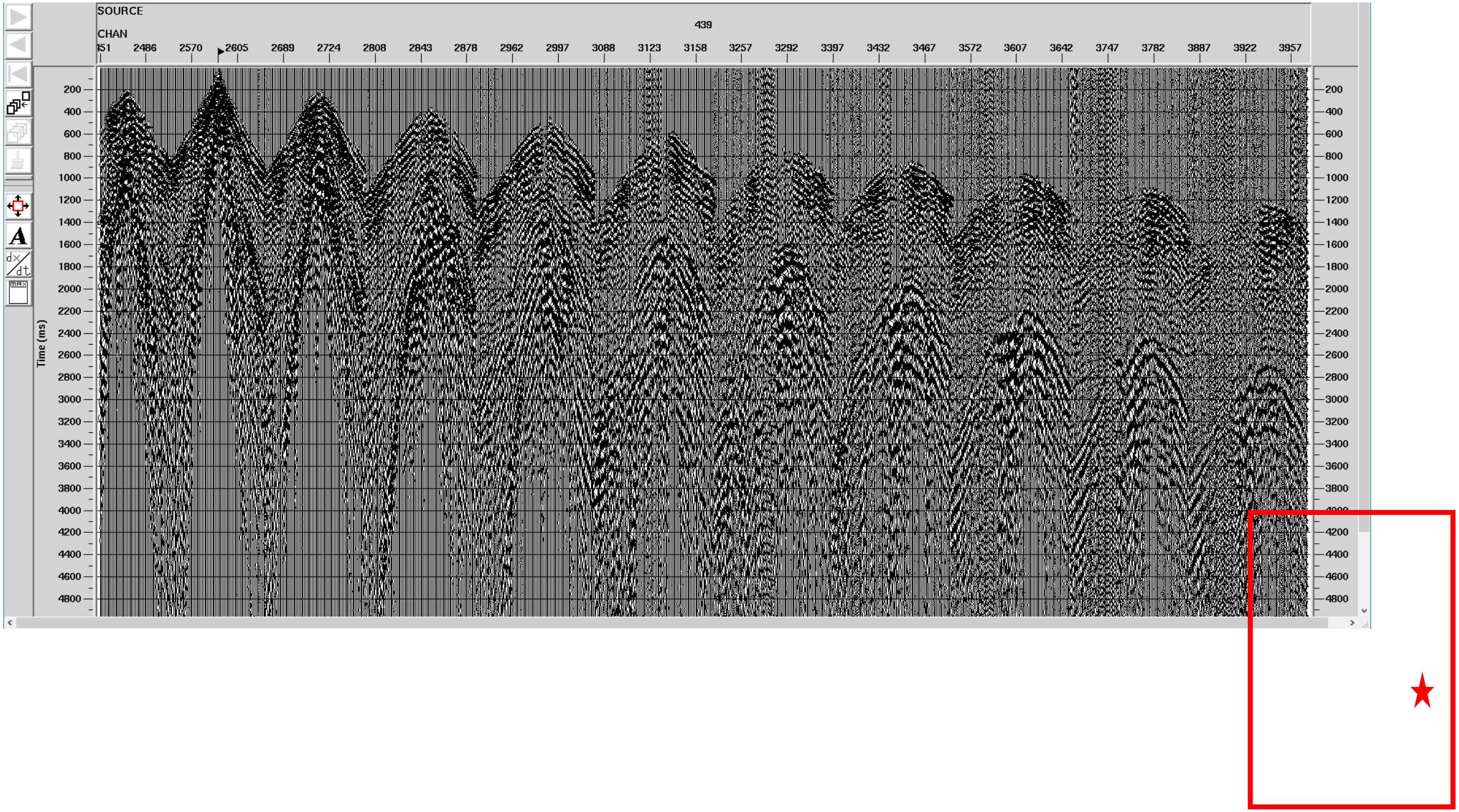
Processing Steps - Fold Map (Nominal=135)



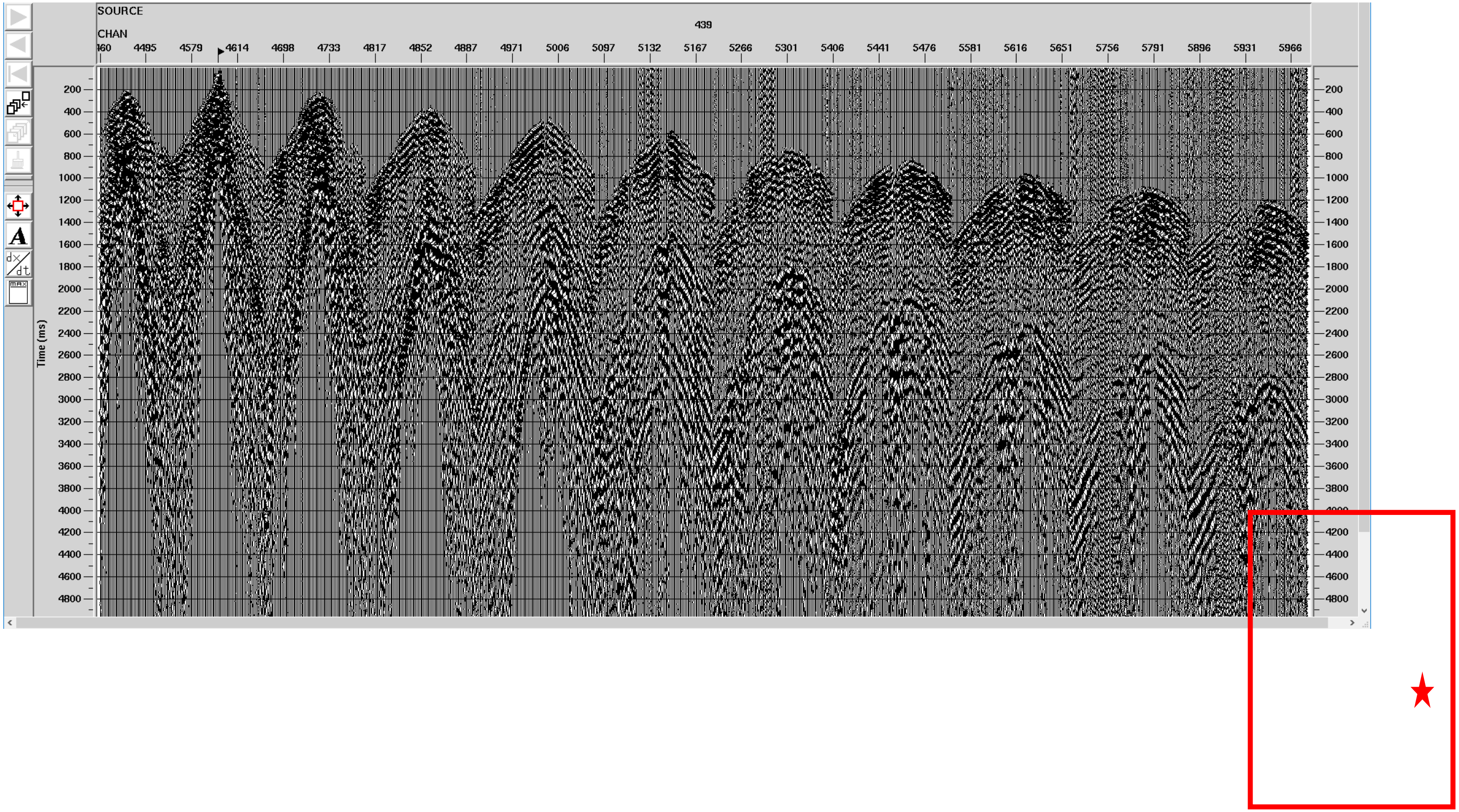
Processing Steps - Shot Gather (Vertical comp.)



Processing Steps - Shot Gather (H1)

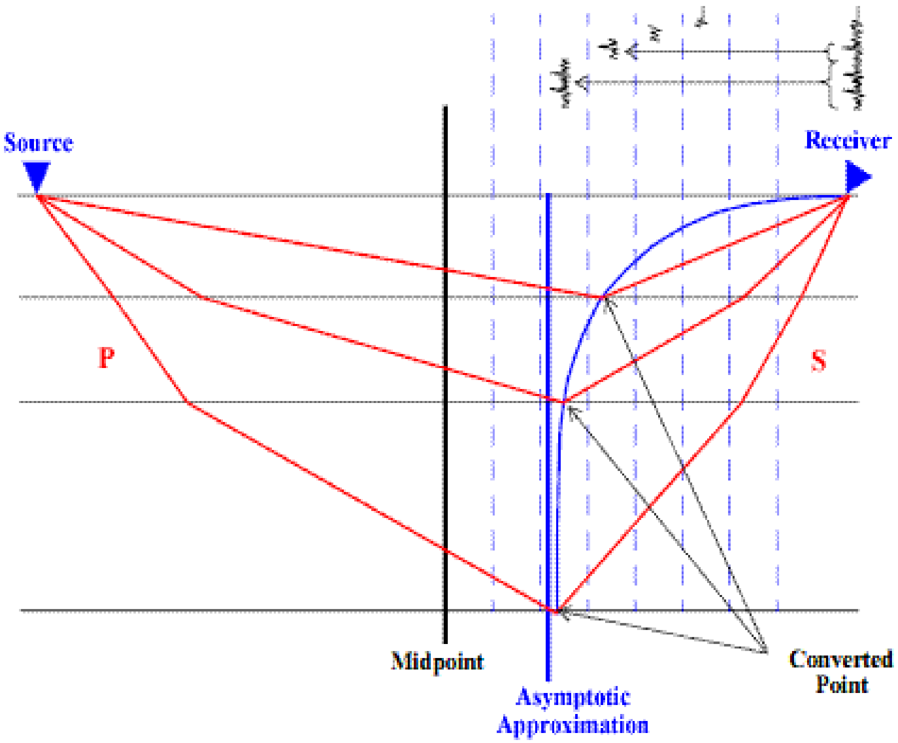


Processing Steps - Shot Gather (H2)



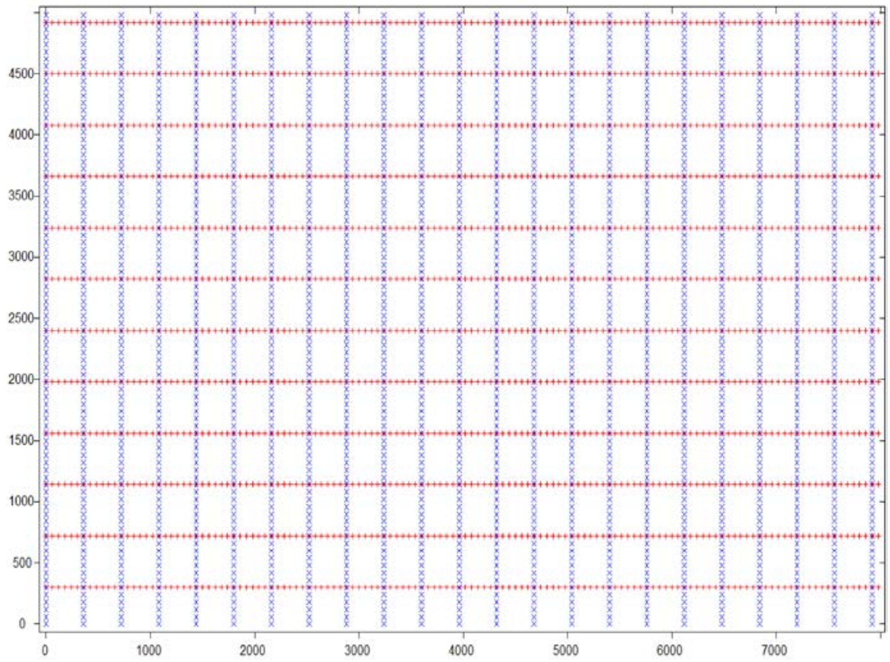
Processing Steps – Binning (CMP and ACP)

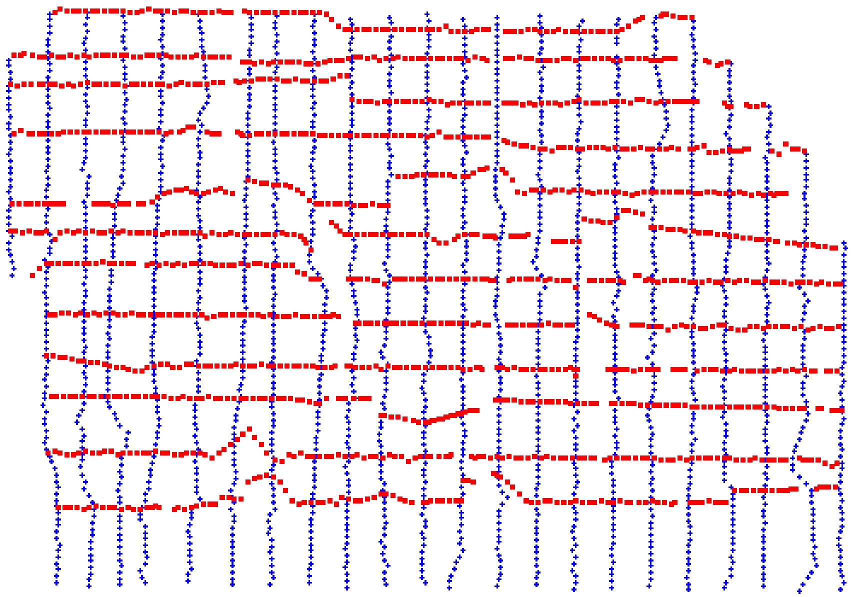
- The raypaths of the converted waves are asymmetric.
- common conversion point (CCP) is considered instead of common mid-point (CMP) in the conventional surveys.
- There different CCP techniques could be used.



Midpoint, Conversion points and asymptotic approximation

Processing Steps – Binning Evaluation





$$Xp = \frac{X}{1 + Vs/Vp}$$

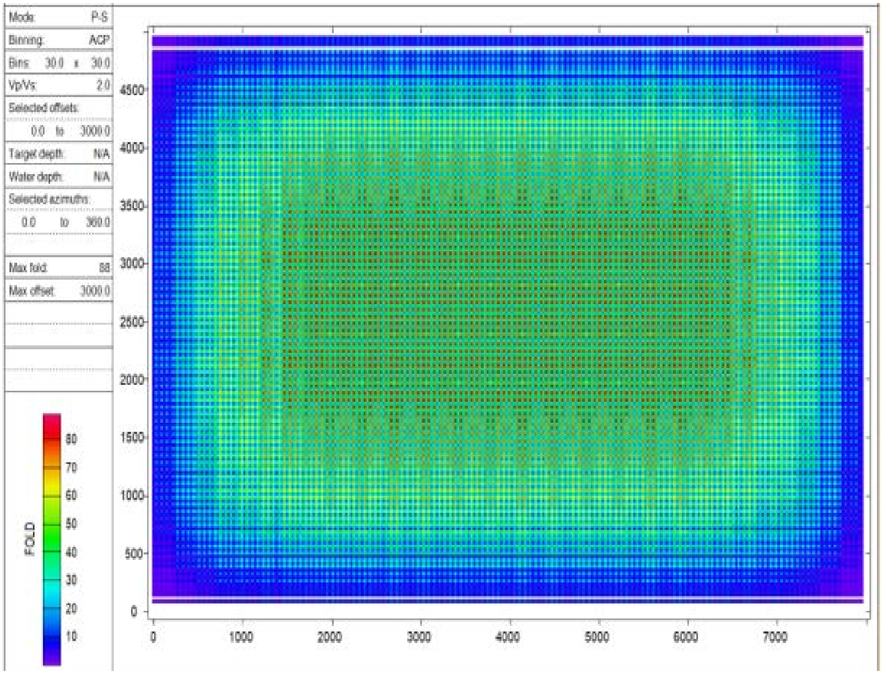
- Xp = the offset from the source to the conversion point
- X = the total source-to-receiver offset
- V_s/V_p = the shear-to-compressional wave velocity ratio in the area.

Processing Steps – Binning Evaluation

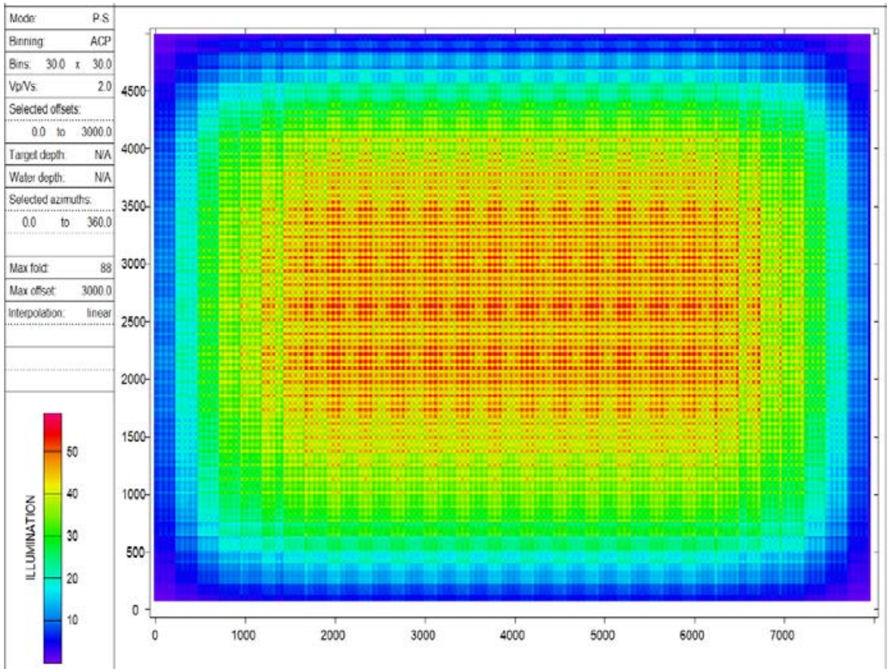
Interval and surface-to-depth V_p/V_s ratios. The row in blue is the measured P-S times, the column in green is the measured P-P times. V_p/V_s at the depth of interest SWH is 2.01. (Weir et al., 2018)

V_P/V_S	2WS	Doe Creek	Wab.	Ireton	Swan Hills	Gill	~Prec	PP time (ms)
Colo	**2.15**	1.99	2.15	2.09	2.05	2.07	2.18	971
2WS	1.991	**2.09**	1.88	1.86	1.981	2.02	2.156	1253
Wab.	2.148	1.88	**2.03**	1.80	1.78	1.94	2.06	1766
Ireton	2.088	1.88	1.80	**2.03**	1.814	2.09	2.06	1933
SWH	2.050	1.981	1.87	1.814	**2.01**	2.411	2.18	2000
Gill.	2.073	2.017	1.93	2.09	2.411	**2.02**	2.02	2068
~Prec.	2.179	2.02	2.06	2.06	2.18	2.02	**2.02**	2151
PS time (ms)	1484	1950	2674	2909	2994	3110	3298	V_P/V_S

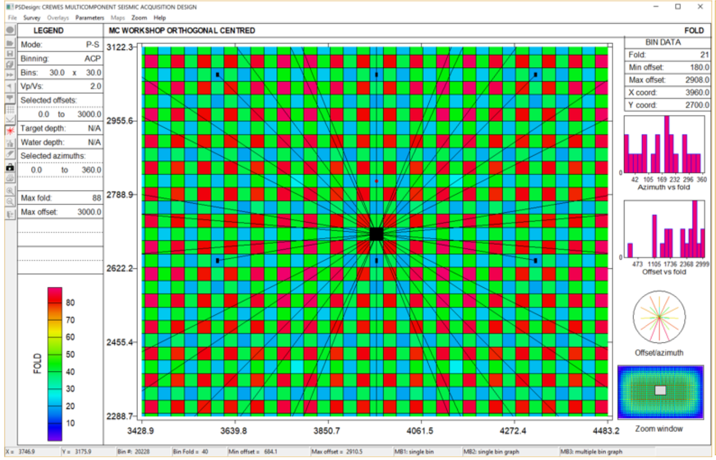
Processing Steps – ACP binning (30m x 30m)

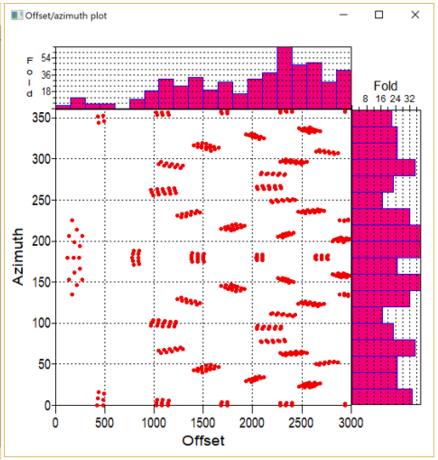


Fold Map



Illumination Map



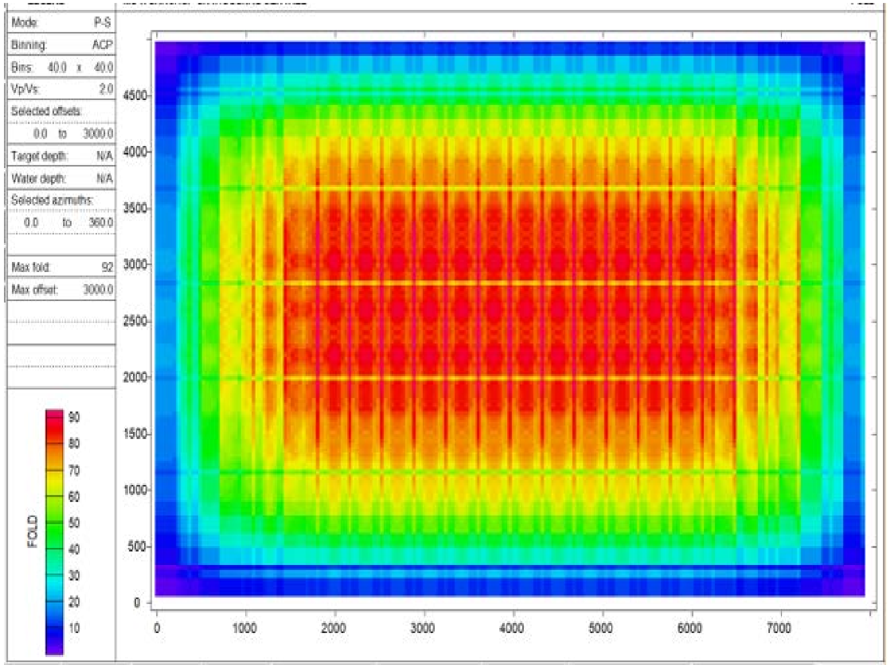


Processing Steps – ACP binning

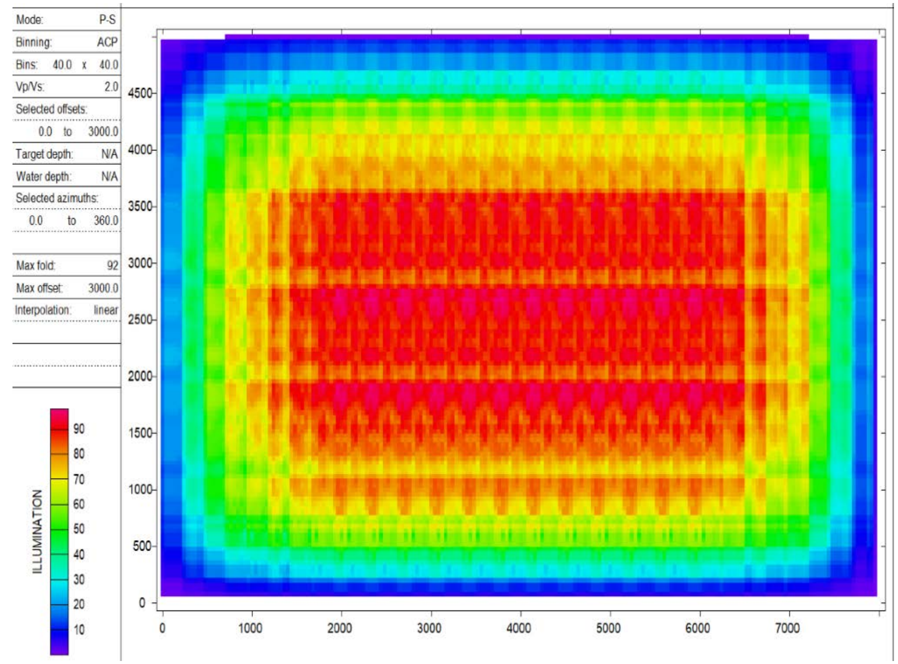
$$\Delta Xc = \Delta r/(1 + \frac{Vs}{Vp})$$

- Δ Xc = bin length in shot/receiver direction.
- Δr = group/source interval.
- Using the equation above, the optimum binning for P-S data is 40m x 40m.

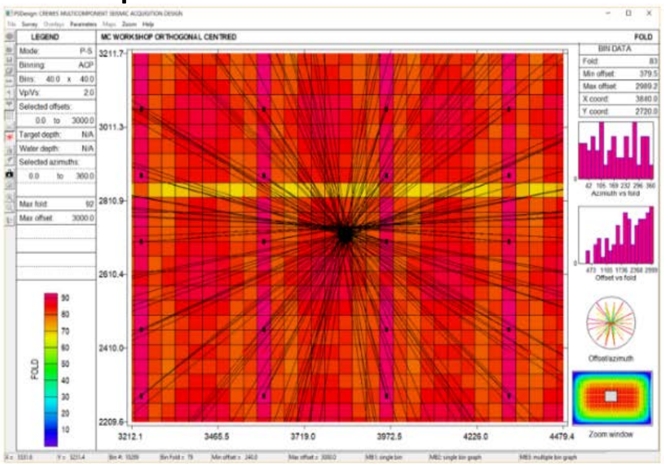
Processing Steps – ACP binning (40m x 40m)

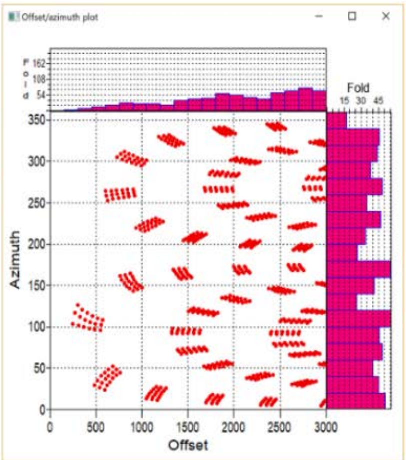


Fold Map

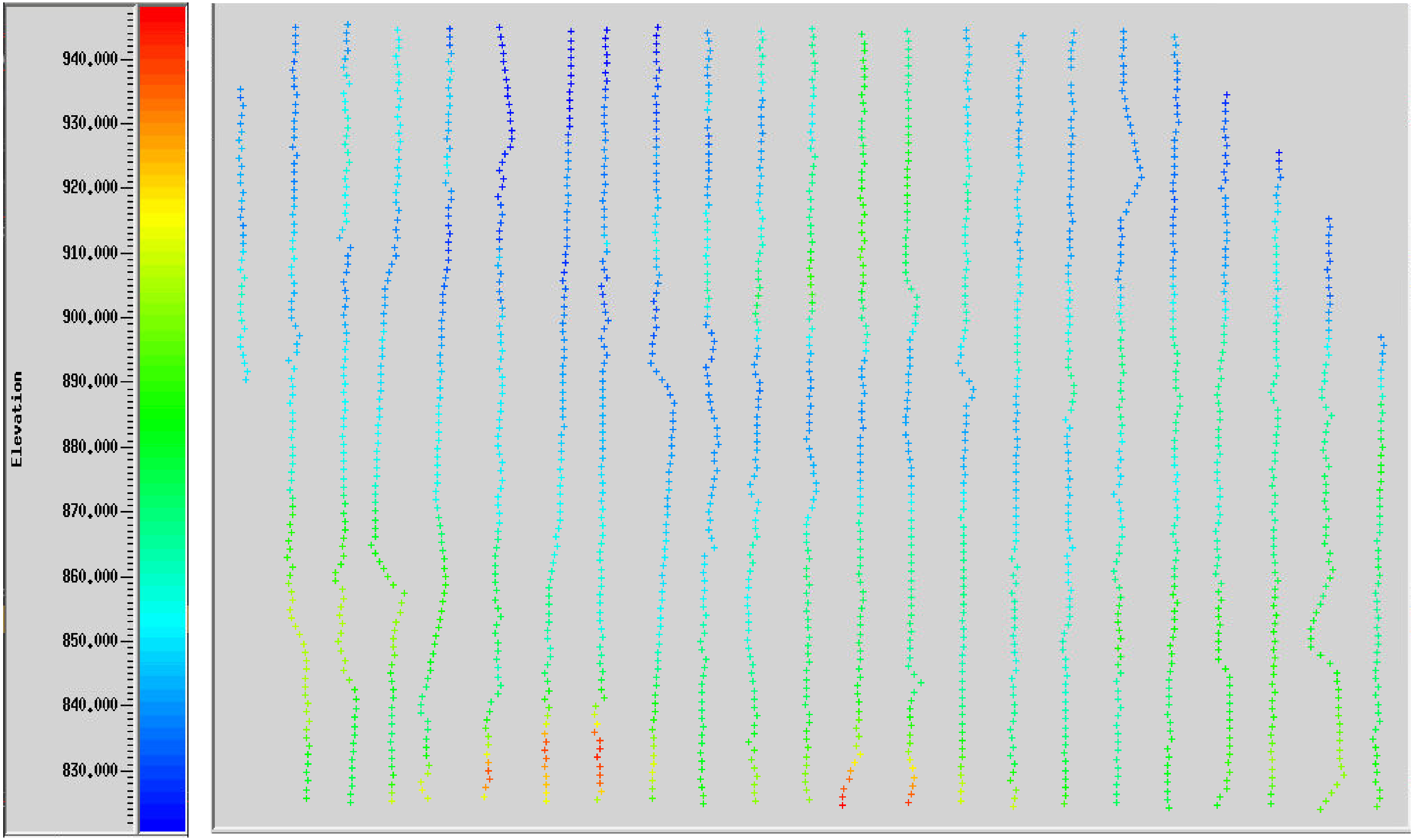


Illumination Map





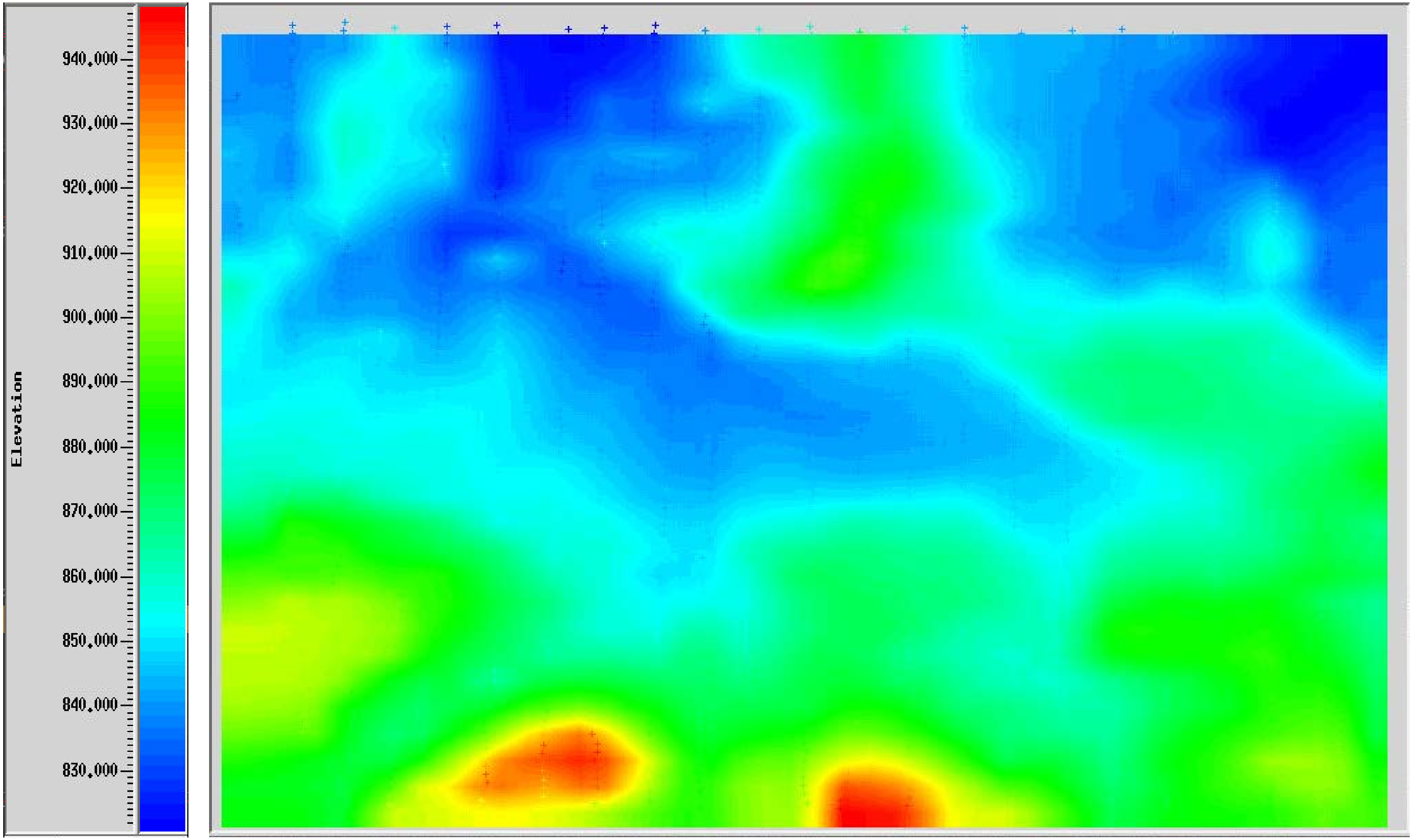
Elevation



Receiver elevation (821 m – 947 m)

CREWES

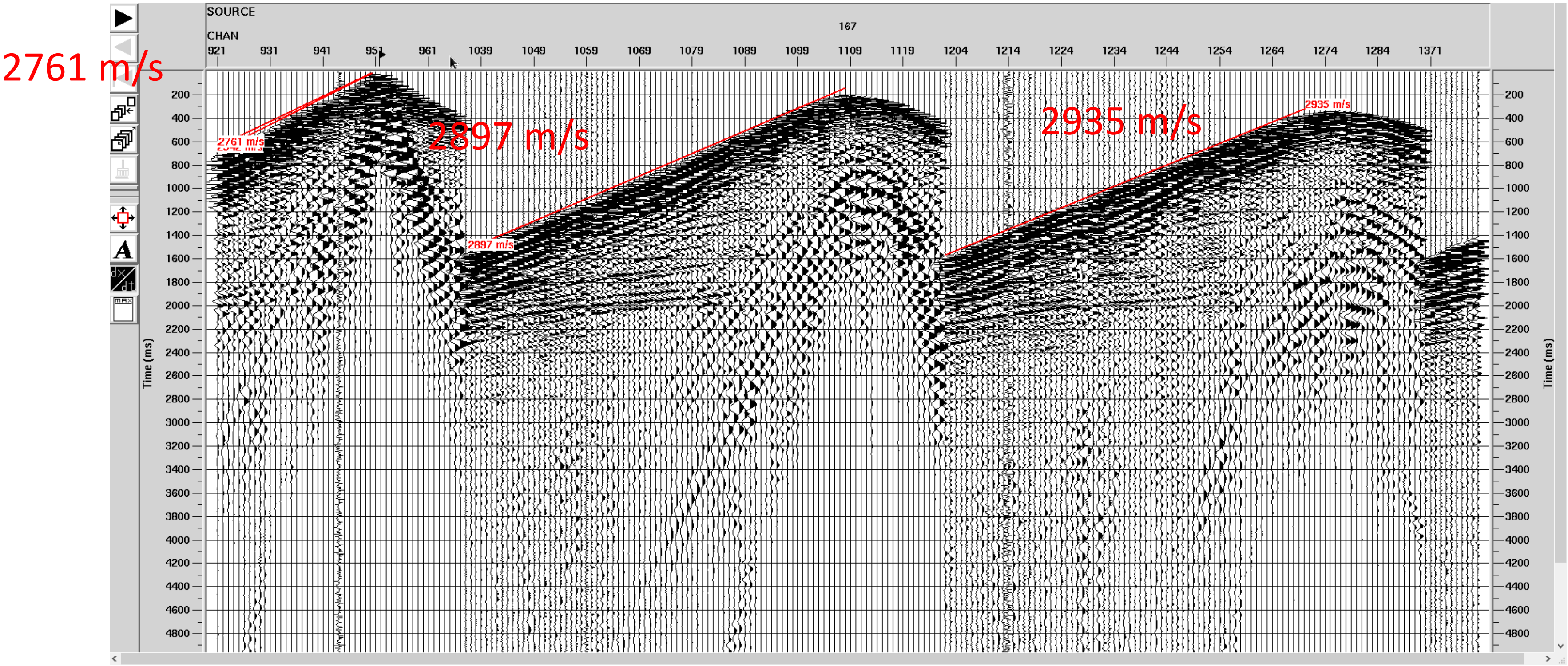
Interpolated Elevation



Receiver elevation (821 m – 947.6 m)

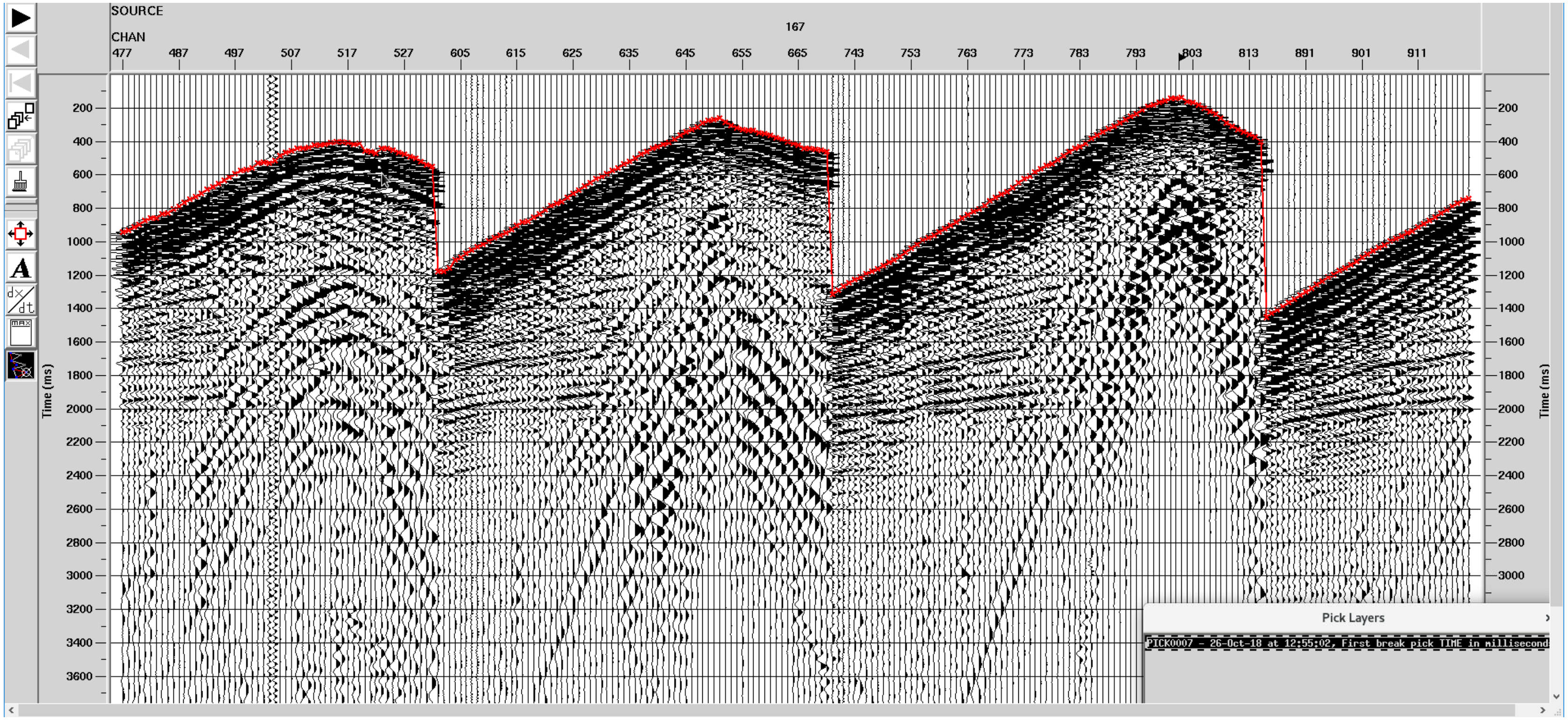
Processing Steps – Elevation Statics

- **Highest elevation = 947.6 m. so floating datum chose to be 950 m**
- **Moveout velocity of the first breaks = ~2800 m/s**

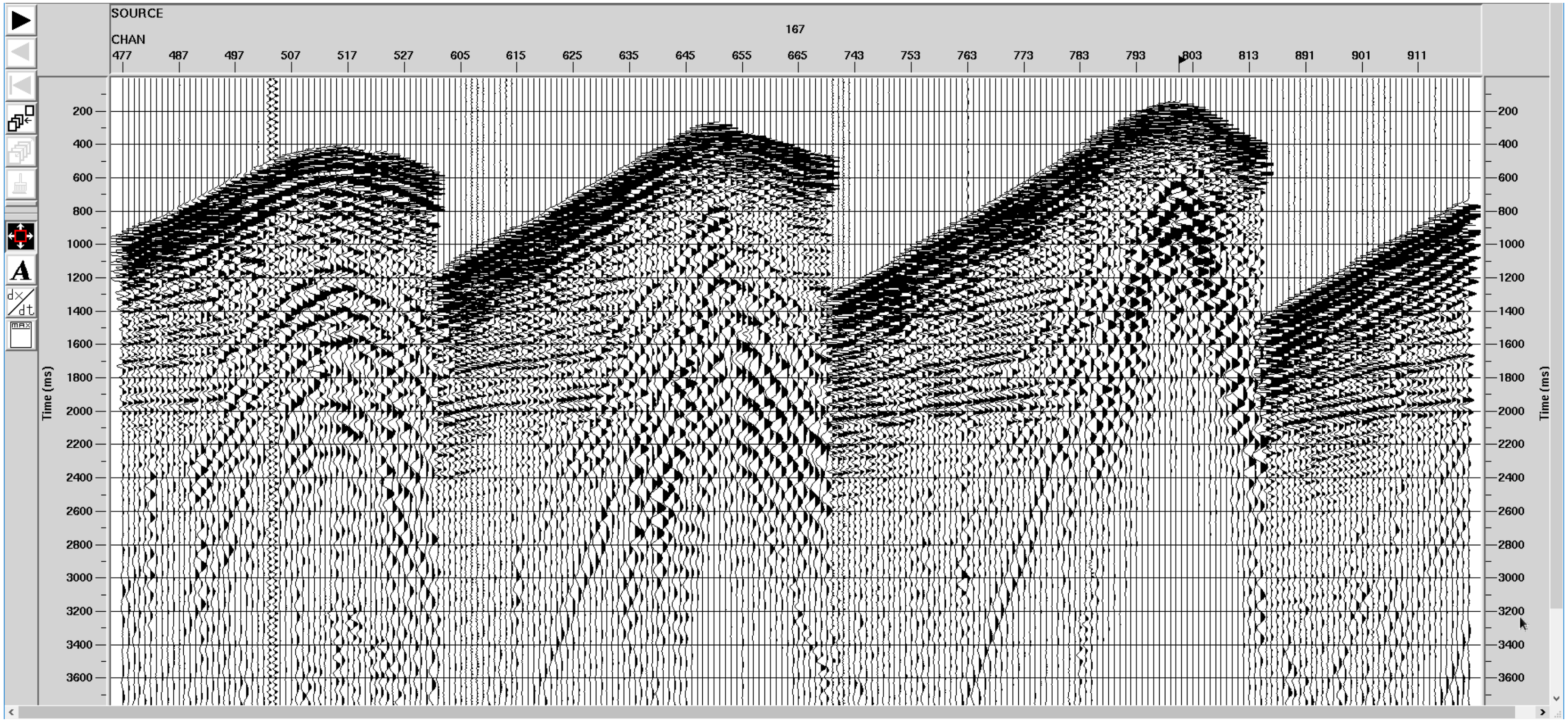


Processing Steps –Refraction Statics

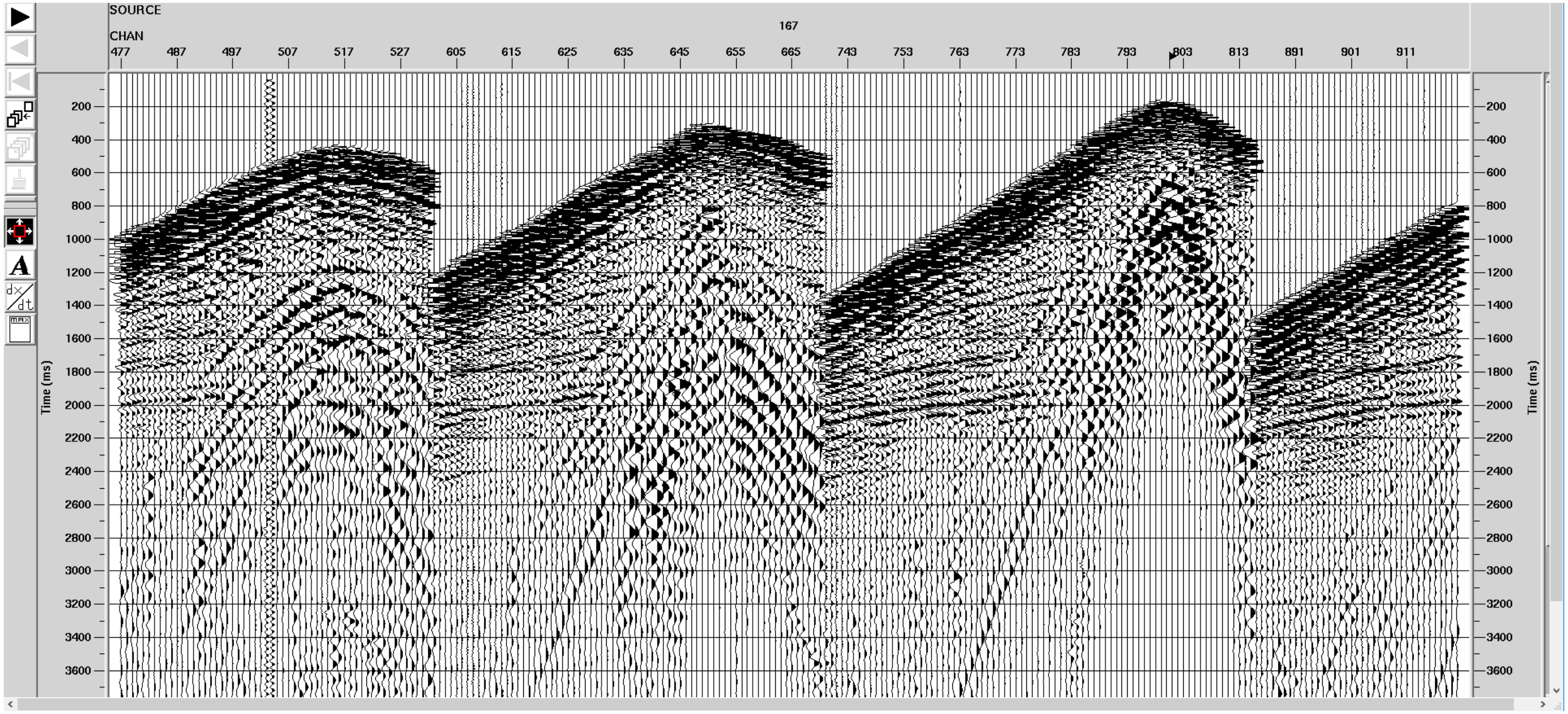
- **Refraction statics were calculated based on FB picks**
- **Weathering layer velocity = 700 m/s**



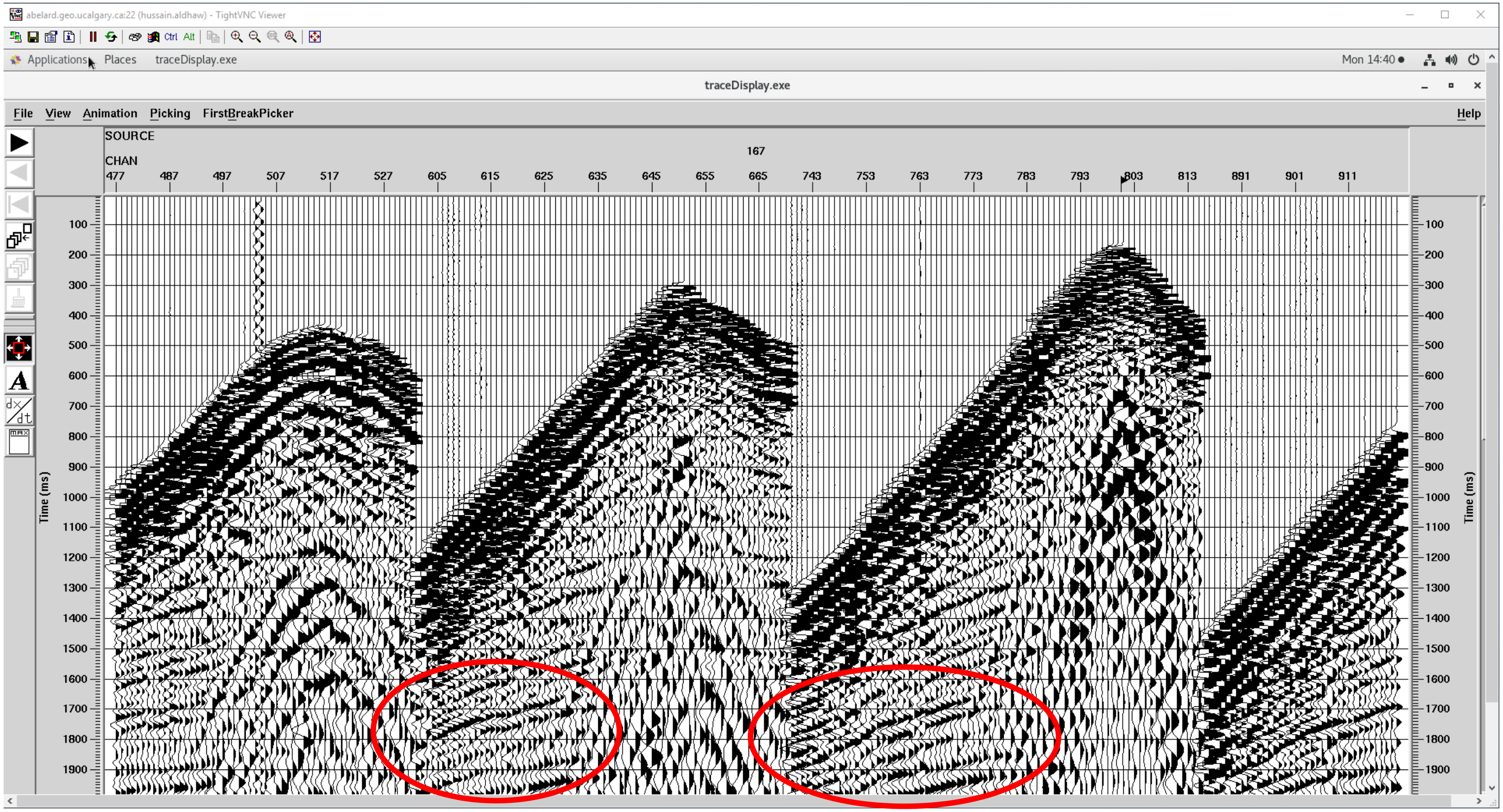
Before elevation and refraction statics



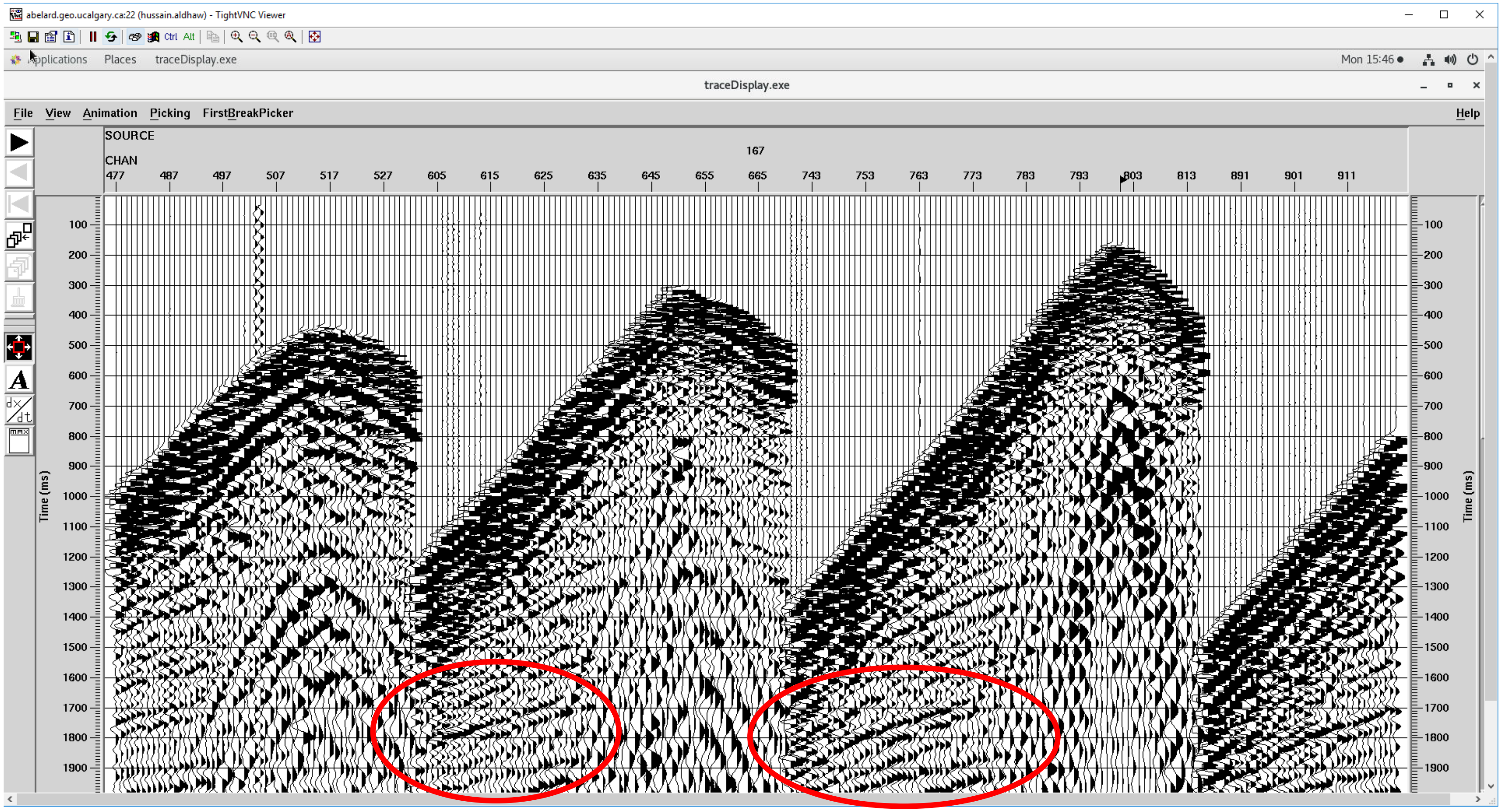
After elevation and refraction statics



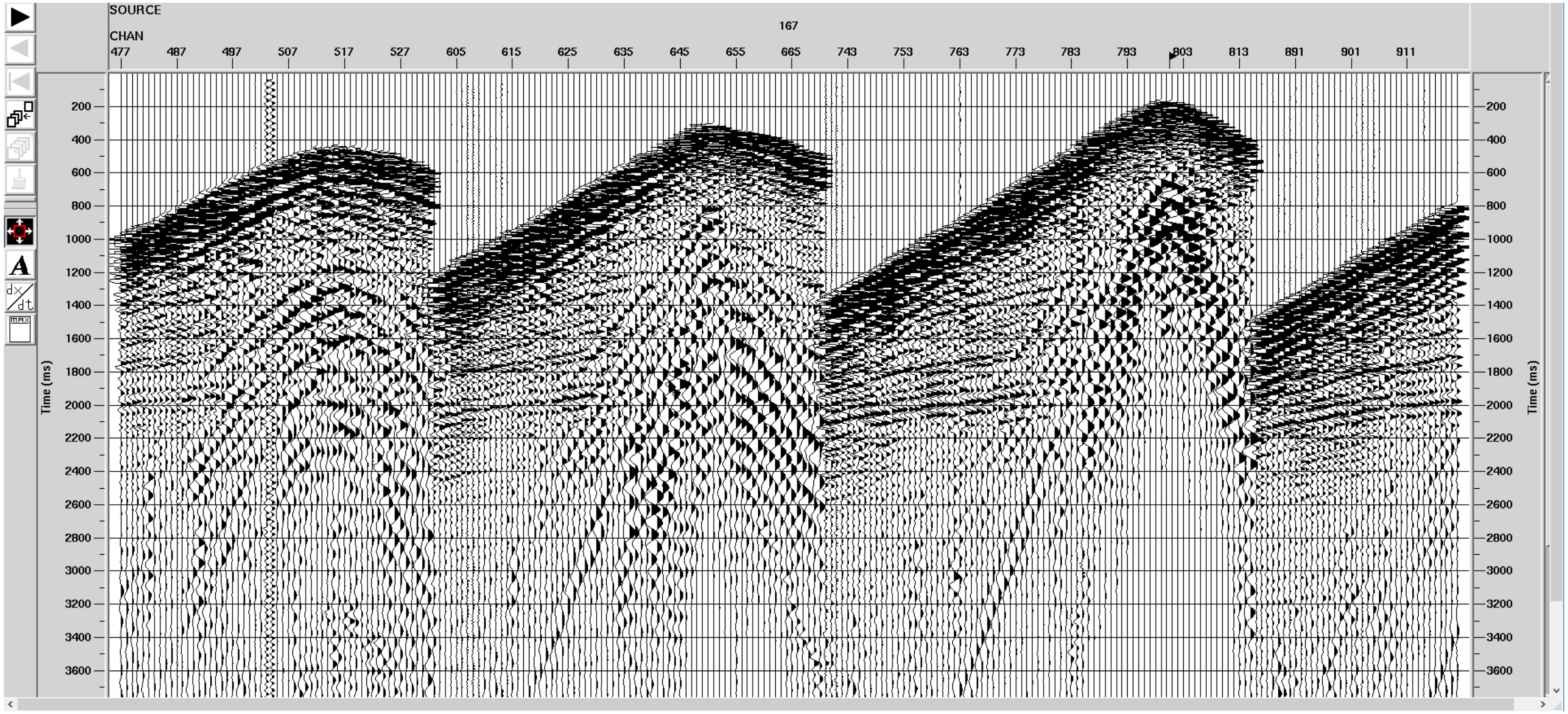
Before elevation and refraction statics



After elevation and refraction statics

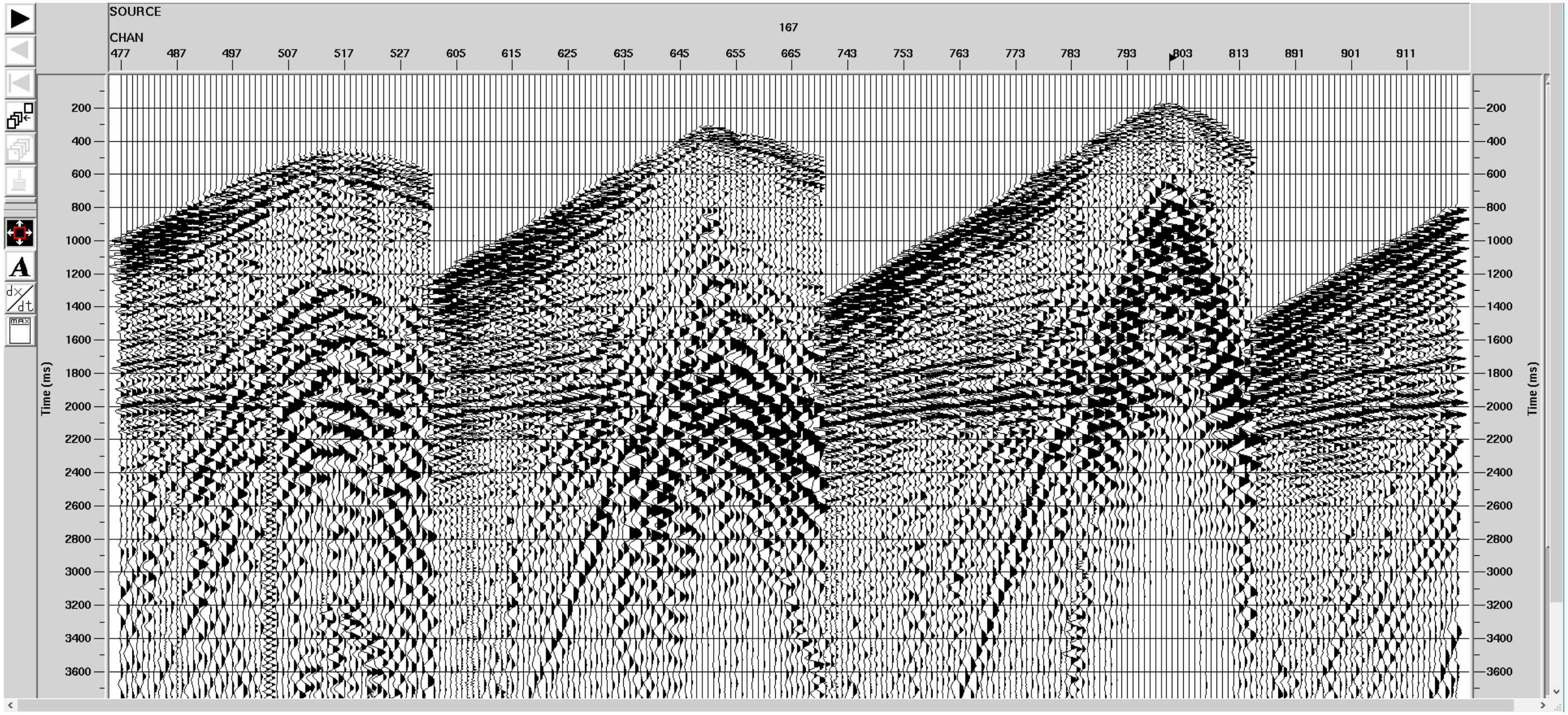


After elevation and refraction statics



Processing Steps – Gain Recovery and SCAC

- **Components decomposed: shot, rec, offset, CDP.**
- **Components used: shot, rec.**



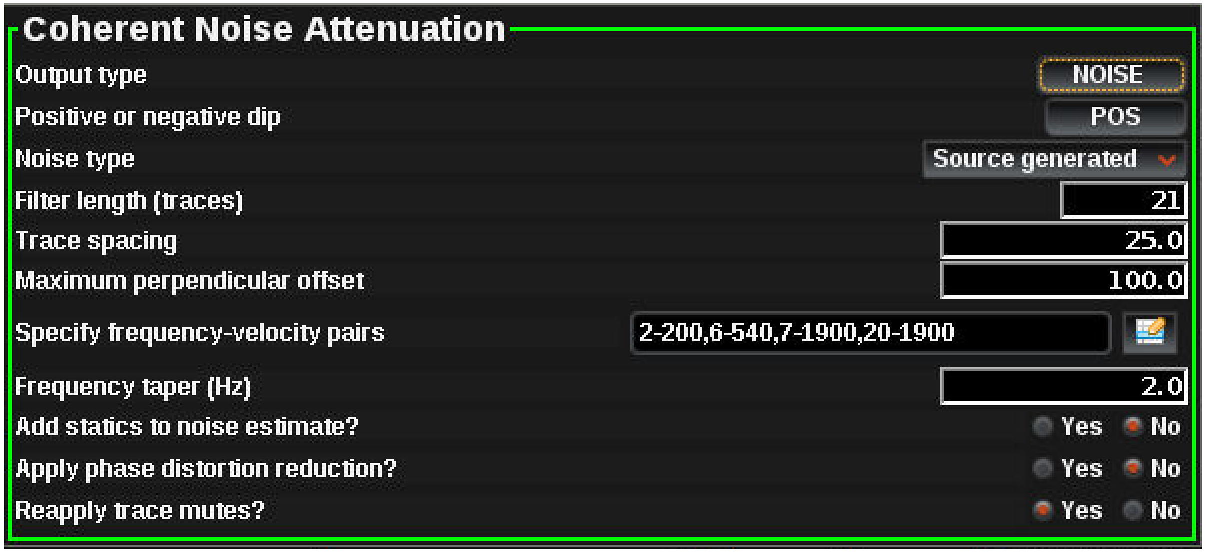
Processing Steps – Pre-decon NA Workflow

Coherent Noise Attenuation

Surface Wave Noise Attenuation

Bandpass Filter

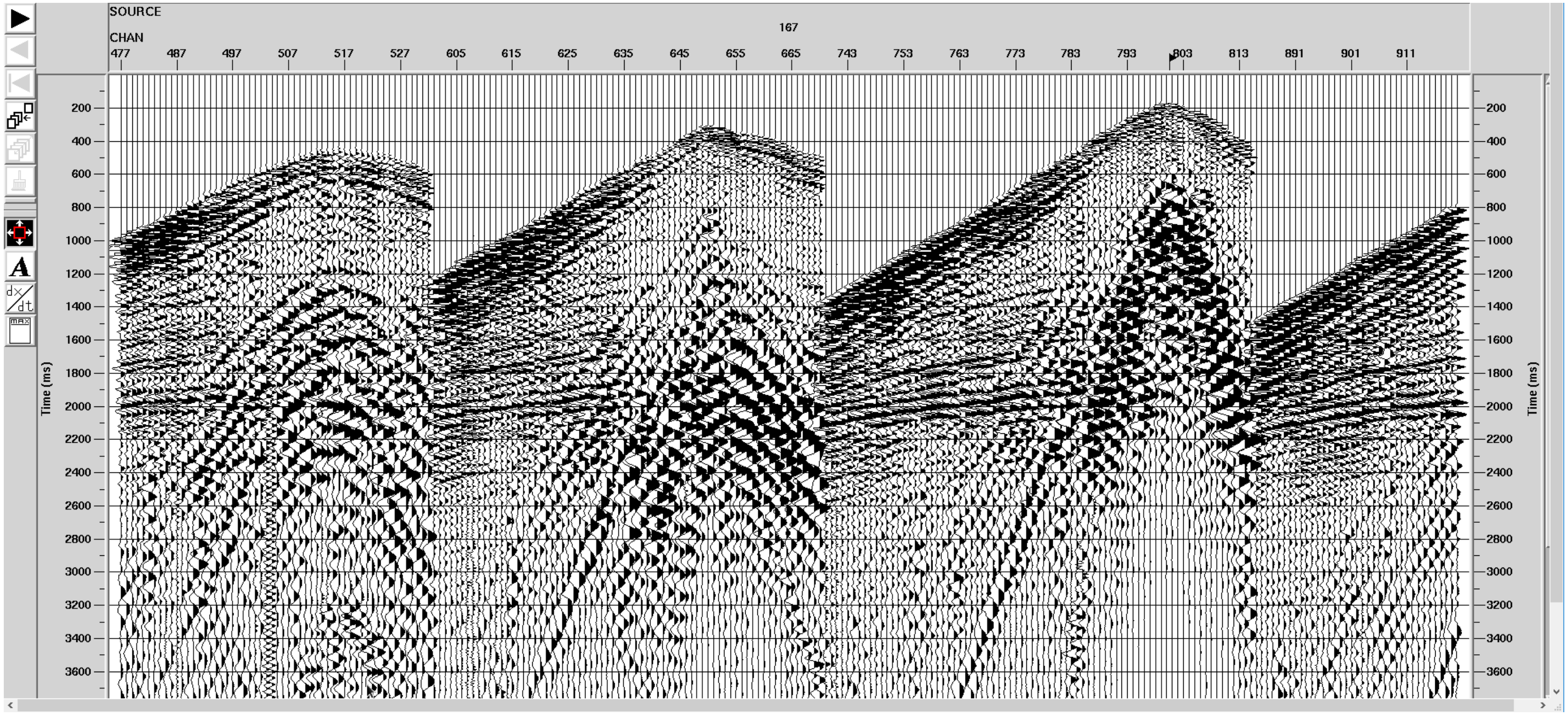
Processing Steps – Coherent Noise Attenuation



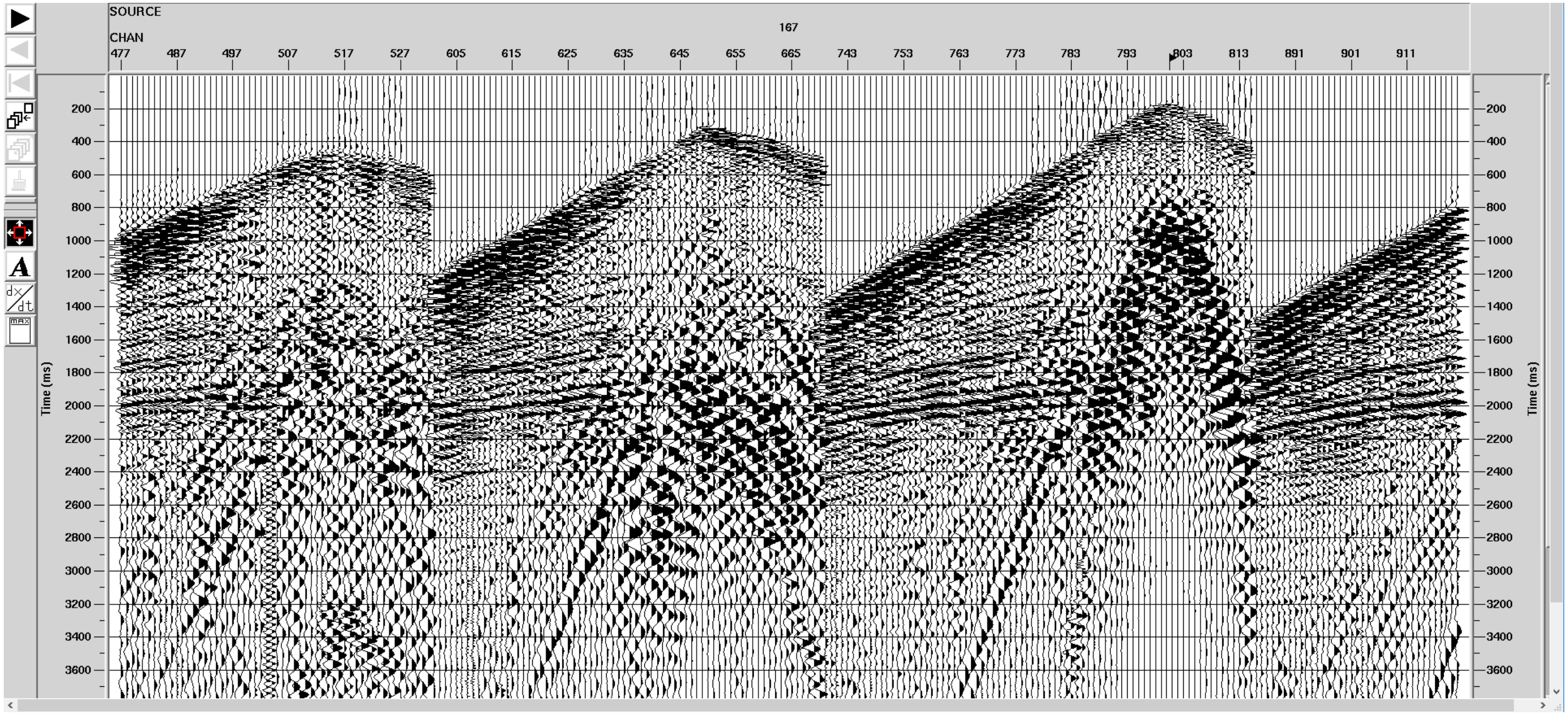
Processing Steps – Coherent Noise Attenuation (2-200)

Processing Steps – Coherent Noise Attenuation (6-540)

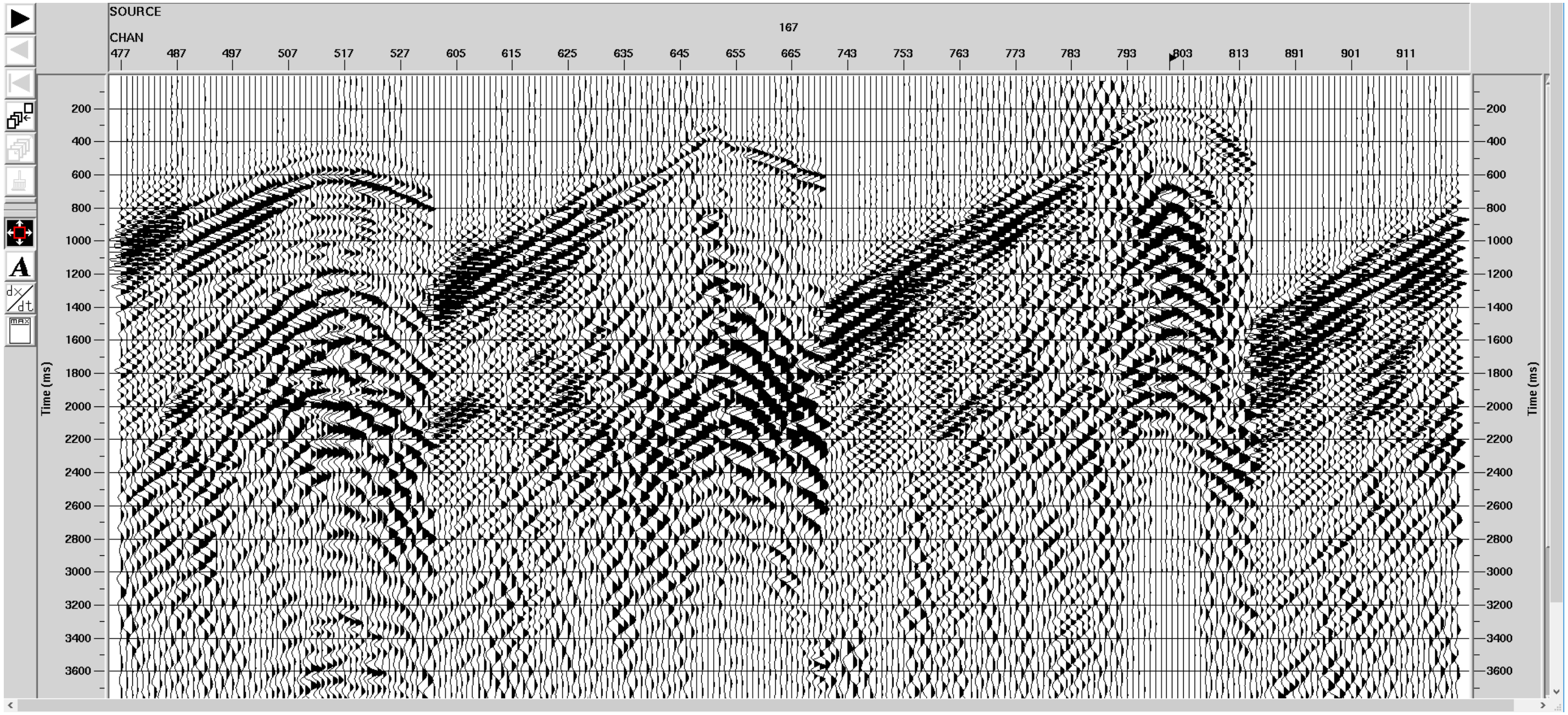
Processing Steps – Gain Recovery and SCAC



Processing Steps – Coherent Noise Attenuation

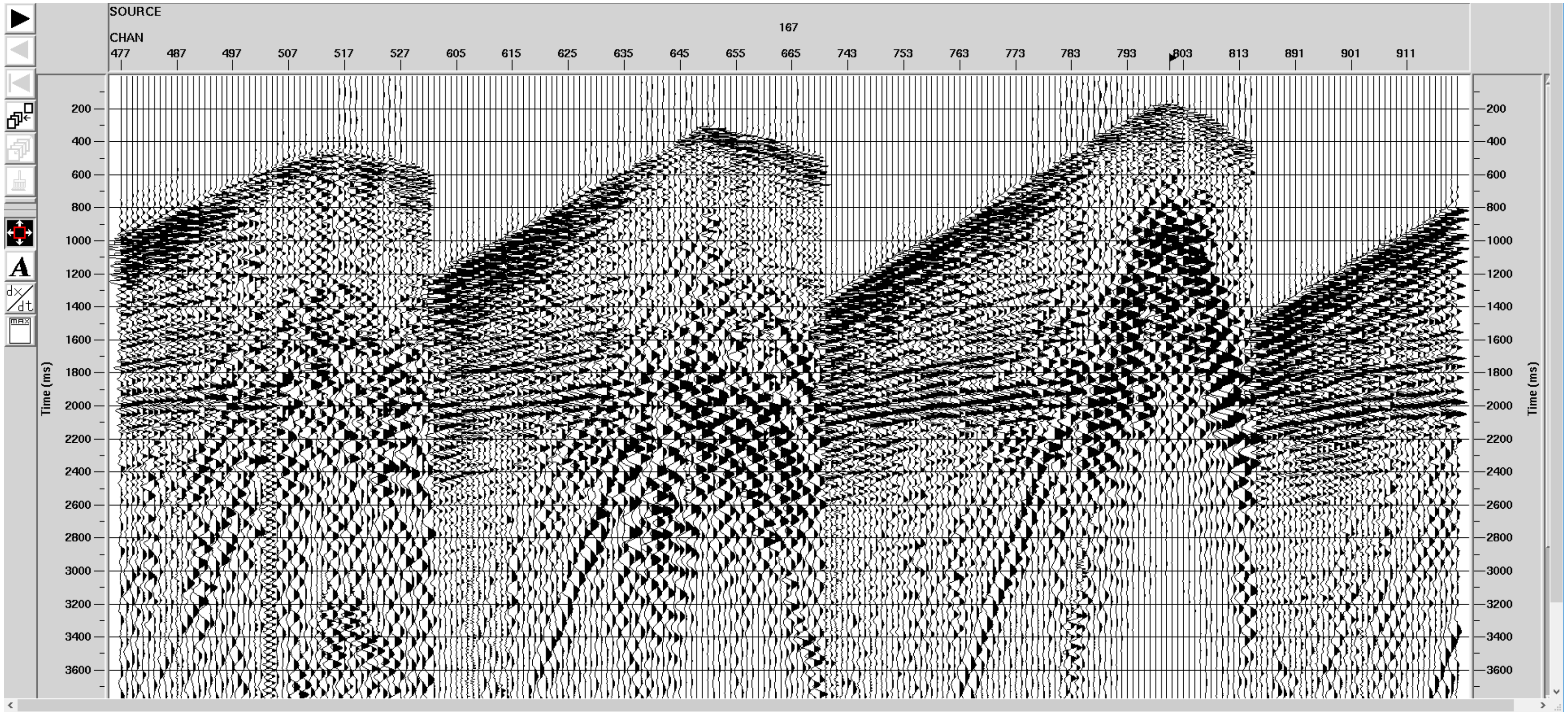


Processing Steps – Difference (Noise removed)

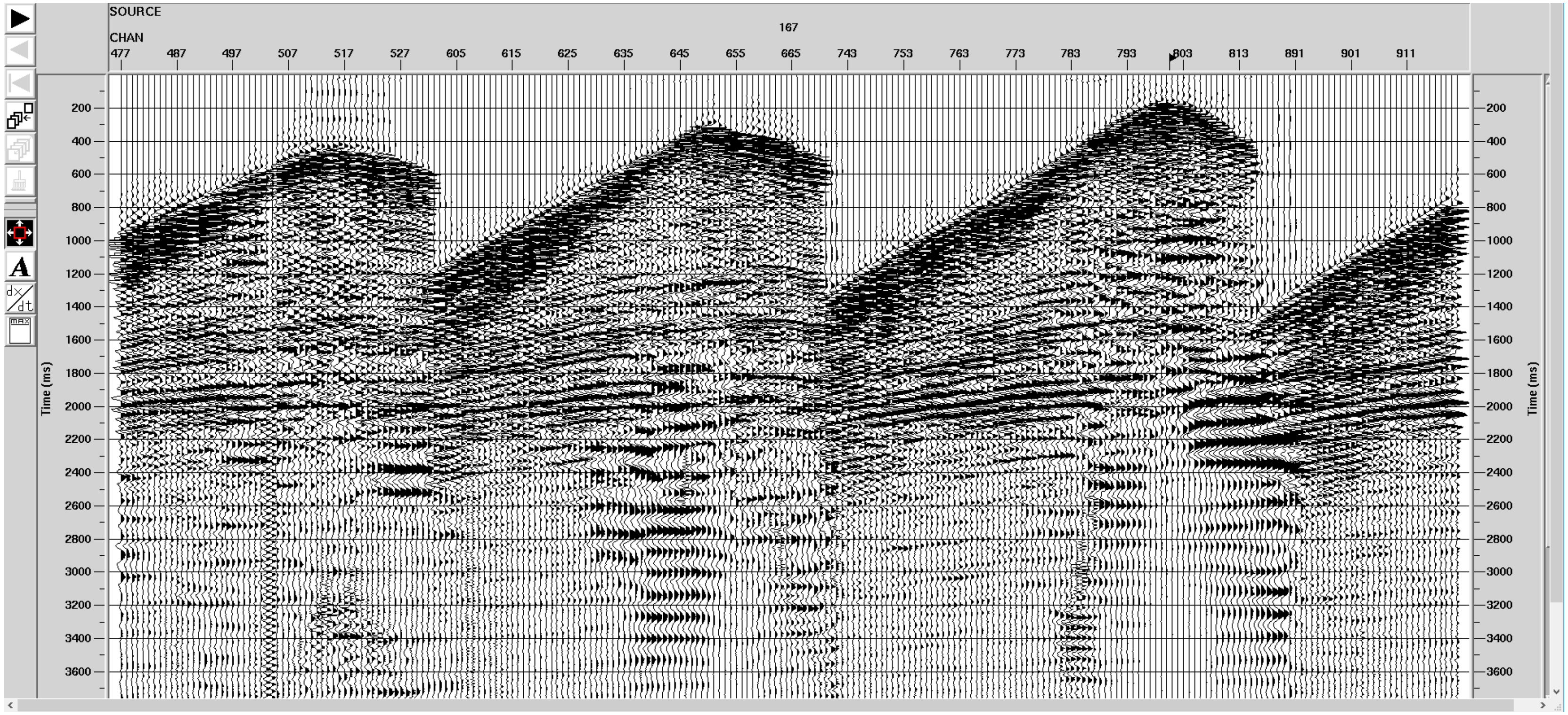


Processing Steps – Surface Wave NA (V=2300 m/s)

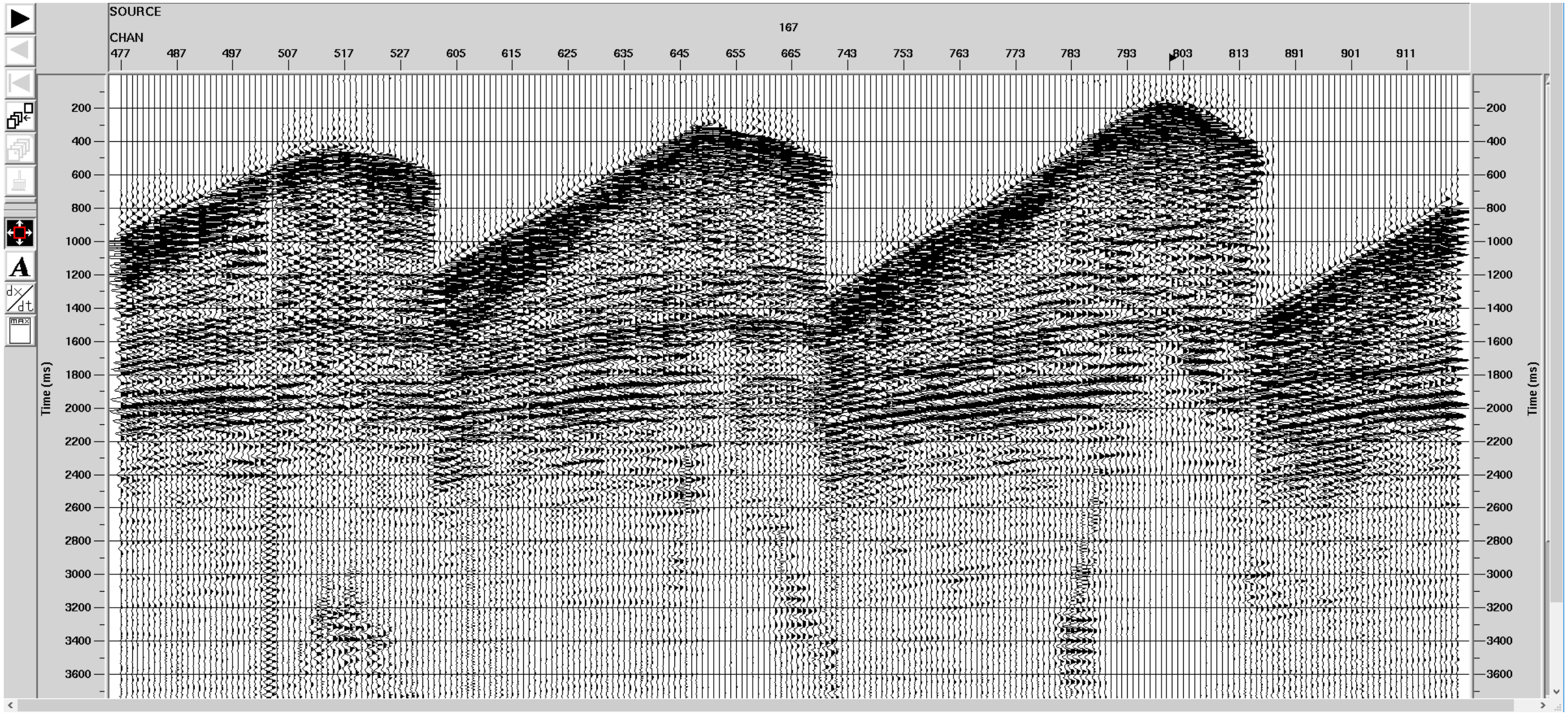
Processing Steps – Coherent Noise Attenuation



Processing Steps – Surface Wave NA

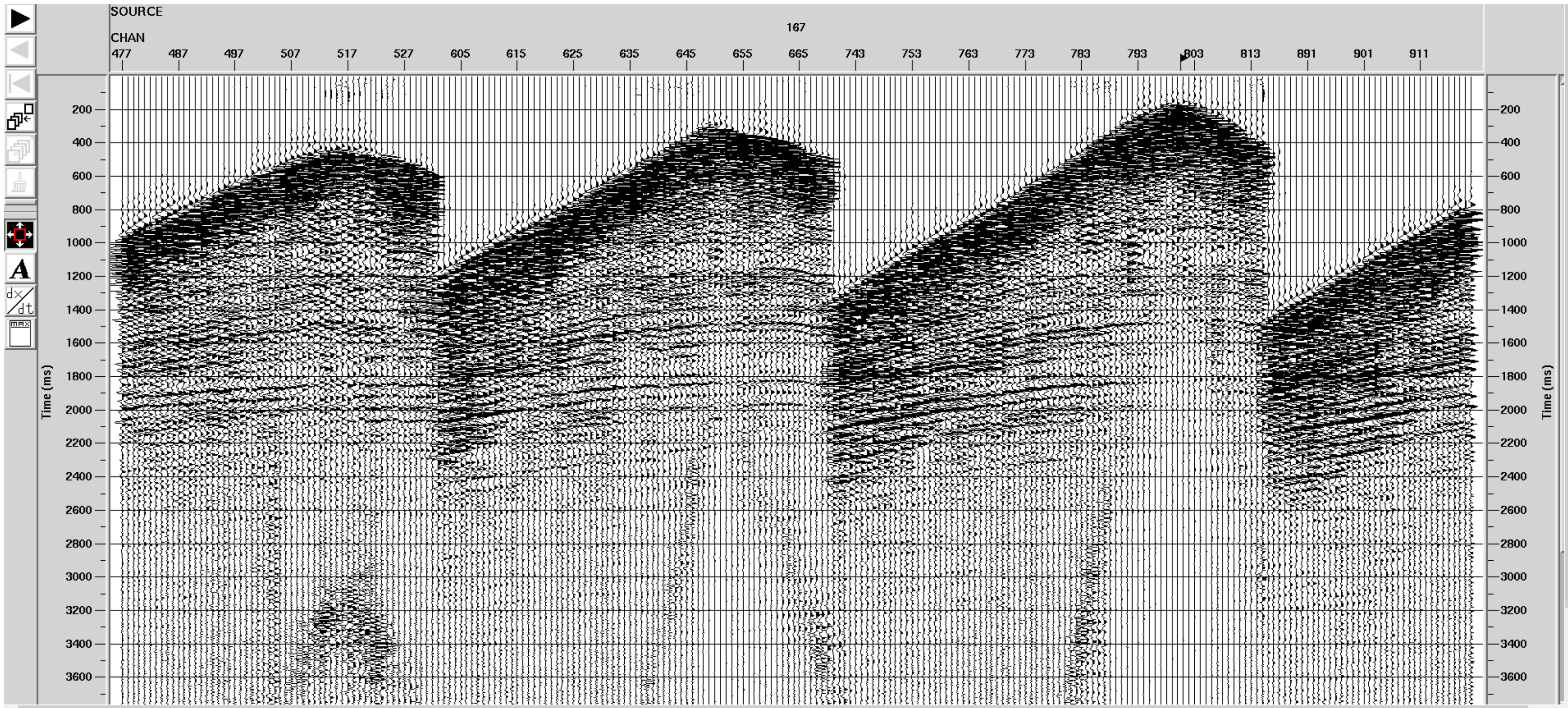


Processing Steps – BP (8,12.5,350,400)

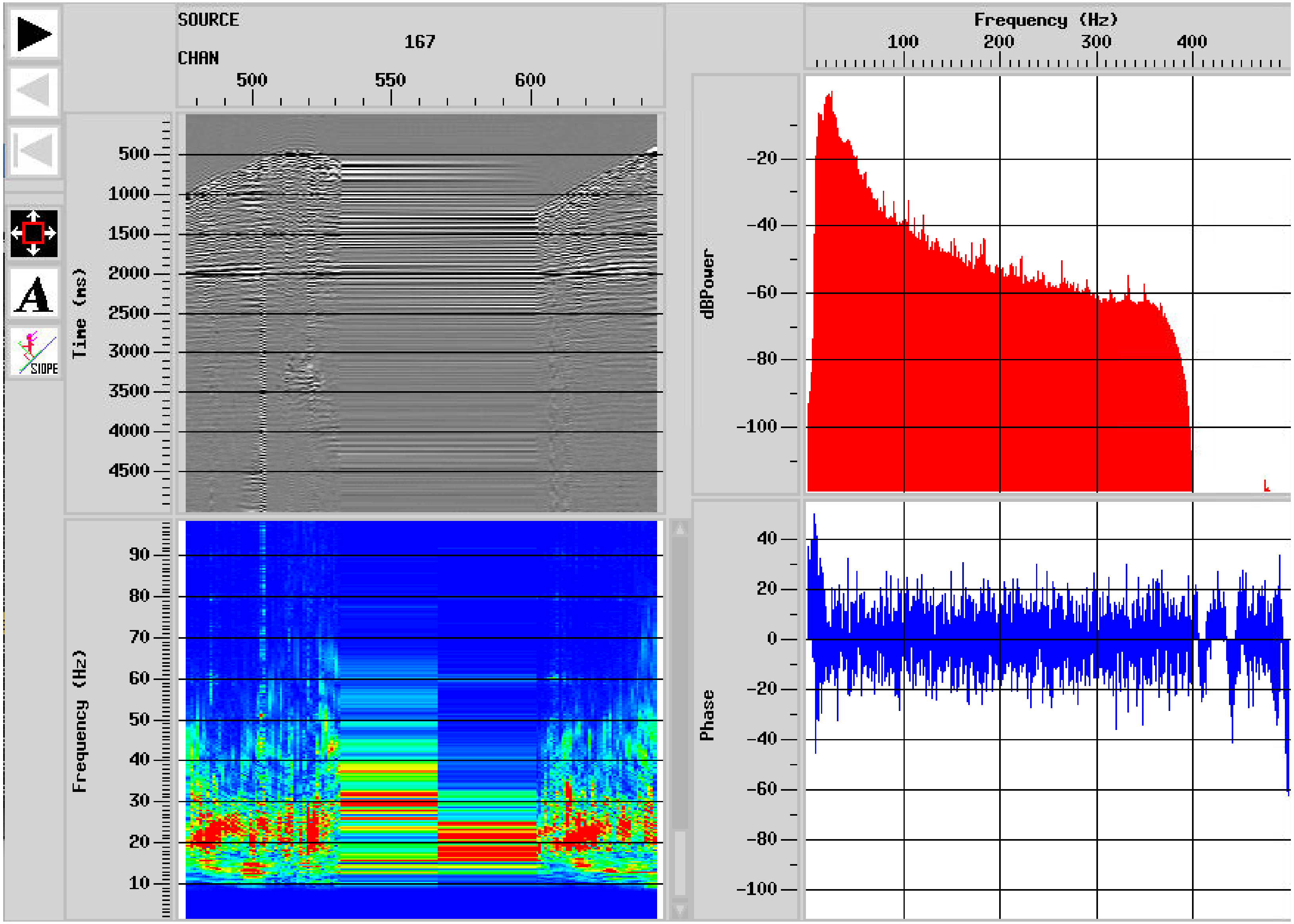


Processing Steps – Surface Consistent Decon

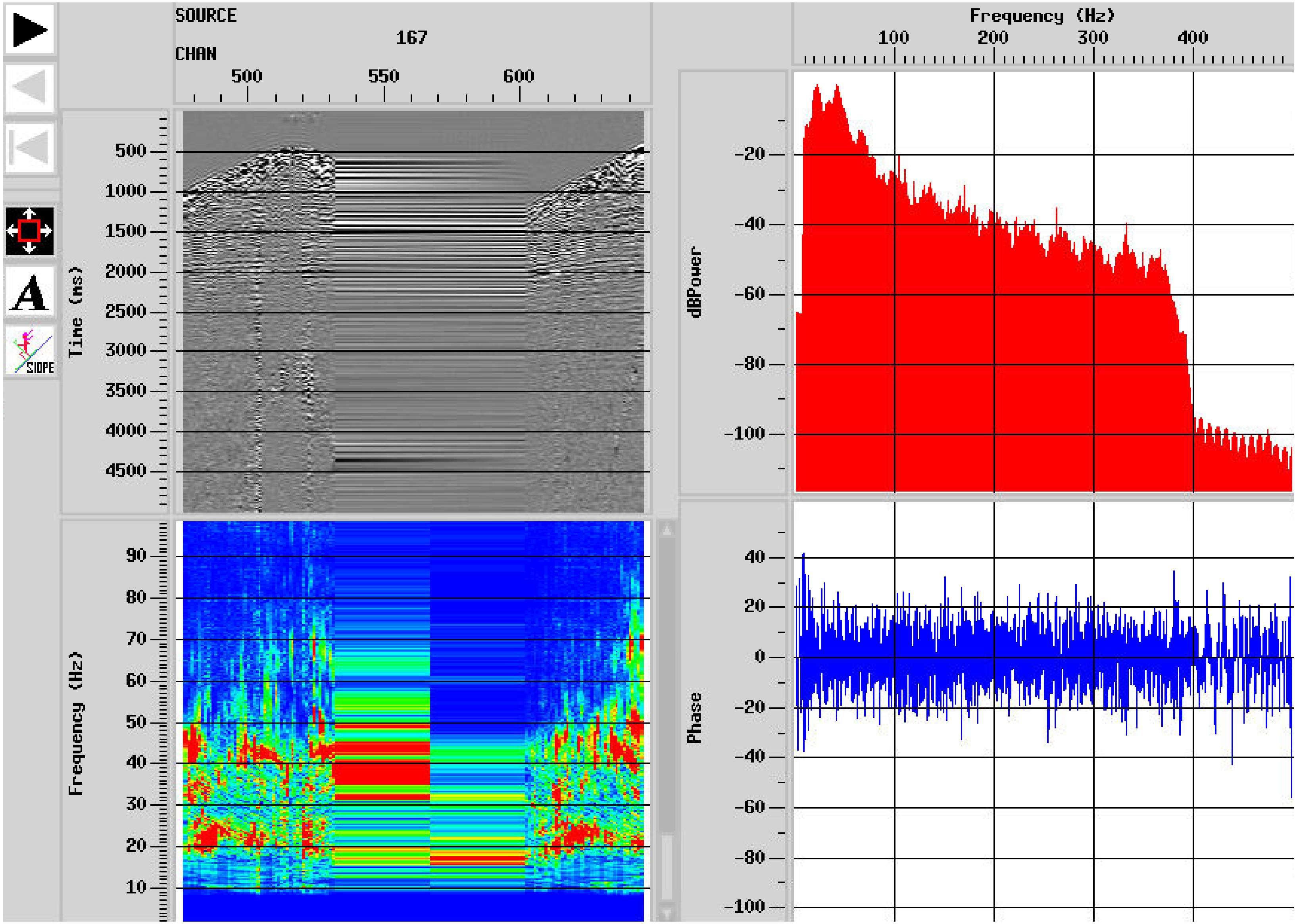
- **Decon operator length = 120 ms**
- **Operator white noise level = 0.1%**



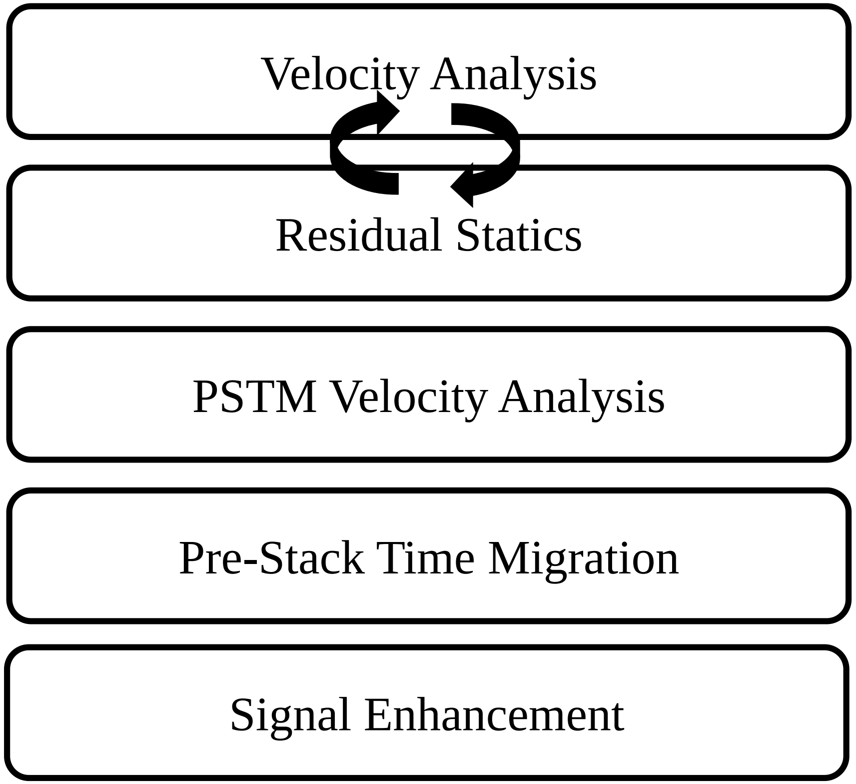
Processing Steps – without SCD (Spectral Analysis)



Processing Steps – with SCD (Spectral Analysis)



Future Work


Velocity Analysis
Residual Statics
PSTM Velocity Analysis
Pre-Stack Time Migration
Signal Enhancement

Acknowledgement

- Dr. Donald Lawton
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- Kevin Hall
- CREWES sponsors
- Saudi Aramco