Seismic data processing of Pikes Peak time-lapse surveys

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Outline

- Survey area
- Processing flow
- S.C.Decon. Time vs. frequency
- Noise attenuation
- PSPI migration
- Conclusions
- Acknowledgments

Survey area

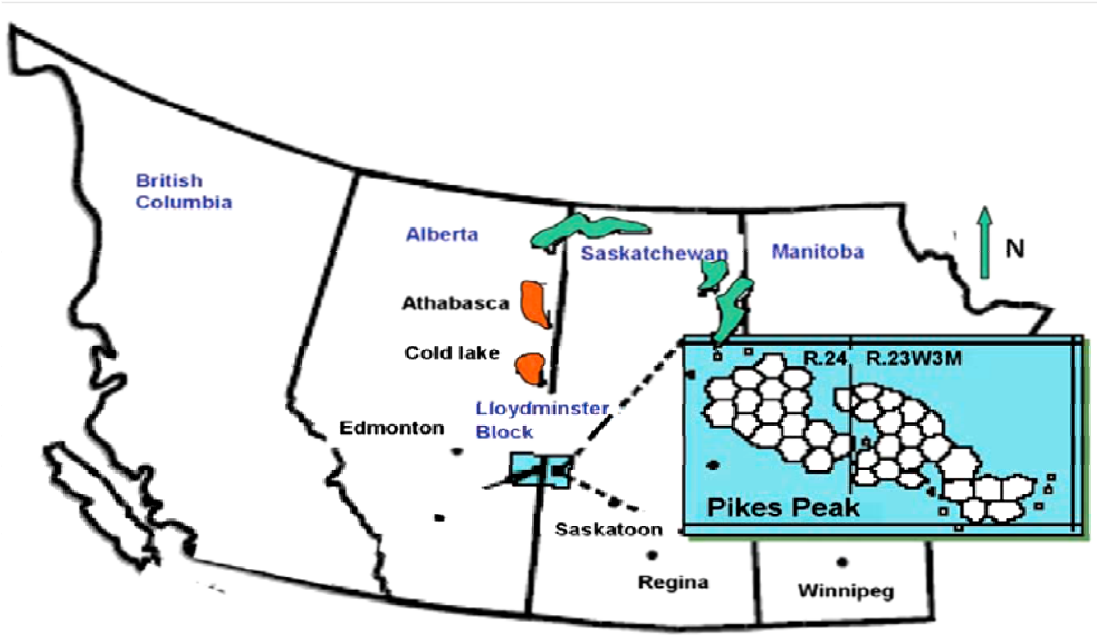

Fig. 1: Location map of the Pikes Peak oil field (*after Watson, 2004*)

- **Pikes Peak survey area -** 40Km east of Lloydminster, AB-SK
- **Heavy oil reservoir - Waseca Formation -**located on E-W structural high within an incised valley-fill channel

- **CSS –** reduce viscosity - increase mobility of oil

Time-lapse survey lines

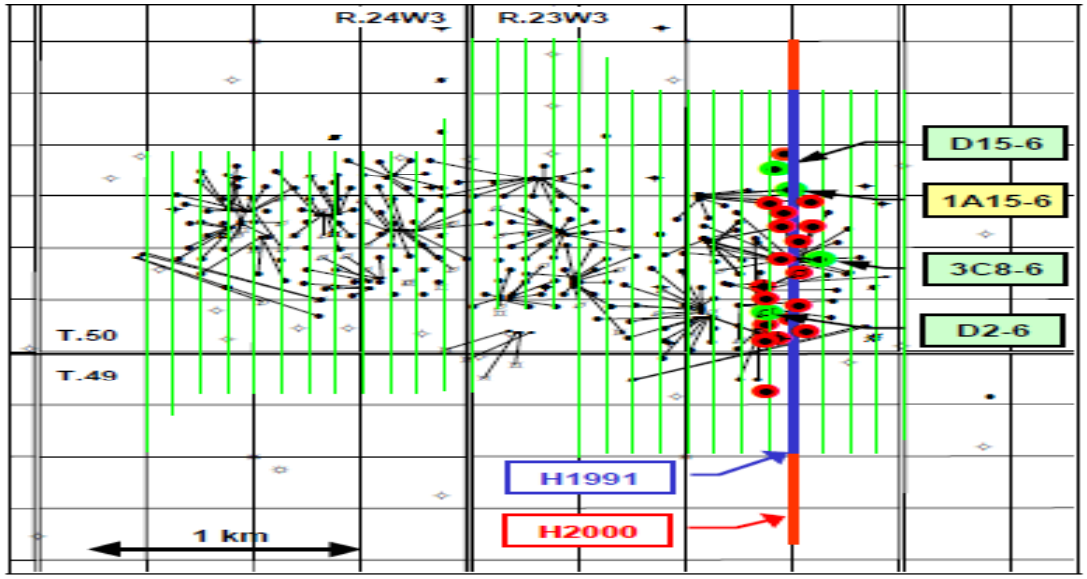

Fig. 2: Right: Pike Peak time – lapse survey lines (*after Watson, 2004*)

- **Survey parameters-**

- Line 1991: - 2.8Km, Shot interval(40m), Receiver interval(20m), Sweep length (8-110Hz), fold (30)
- Line 2000(3C): - 3.8Km, Shot interval(20m), Receiver interval(10m), Sweep length (8-150Hz), fold (60).

Processing flow: Pikes Peak seismic data

- Reformat (done at CREWES) & Geometry assignment
- Amplitude recovery
- Refraction Statics calculation (GLI,GRM,DRM)
- Deconvolution (Surface Consistent Five component deconvolution)
- Noise suppression: Line2000
- Surface Consistent Amplitude Correction
- Apply datum and refraction statics (DRM)
- First pass velocity analysis
- Surface Consistent Residual Statics - 32ms correlation
- Velocity analysis – Half the spacing of first pass (line 91 only)
- Second Pass of Surface Consistent Residual Statics - 16ms correlation
- Final Normal move out
- PSTM gathers preparation
- Pre Stack Time Migration
- Mute & Stack
- Filter & Scale

5-component Surface Consistent Decon

- Individual traces are decomposed in the LS sense into 5 components in the logarithmic spectra.

$$x(t) = l(t) * s(t) * g(t) * h(t) * c(t)$$

and

$$ln[X(f)] = a_L ln[L(f)] + a_S ln[S(f)] + a_G ln[G(f)] + a_H ln[H(f)] + a_C ln[C(f)]$$

- Uniqueness (Wang, 1992):

1. Non-parametric frequency domain min phase decon which gives a whiter spectrum than the parametric Auto Regressive model deconvolution.
2. LS adaptive fitting of a's.
3. In the de-phasing process, convert all instrument and phones into minimum phase, not zero phase.

Surface Consistent deconvolution

- **Line 2000**

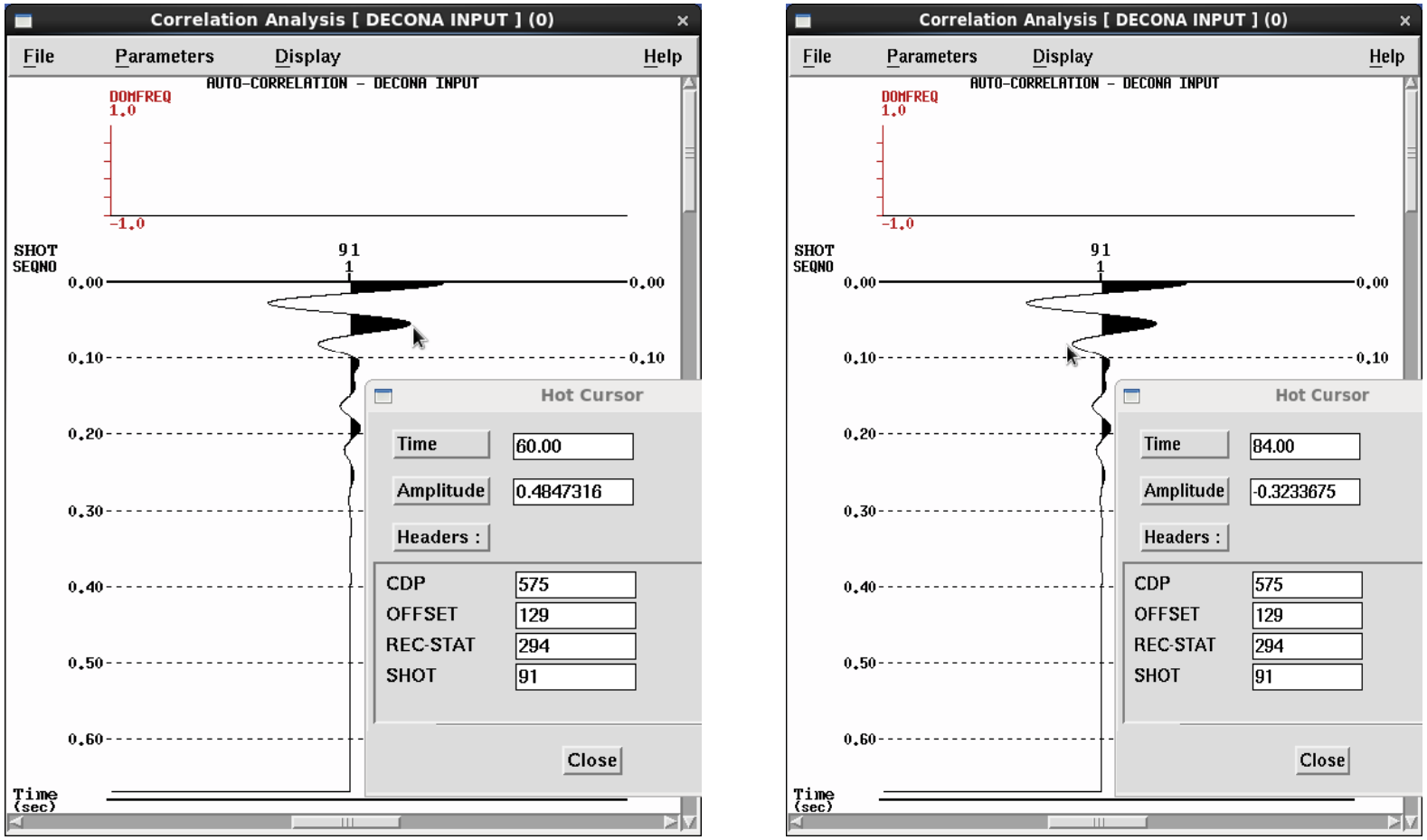

Fig. 3: Correlation analysis window to determine operator length – Time domain

Surface Consistent deconvolution…. continued

- **Line 2000**

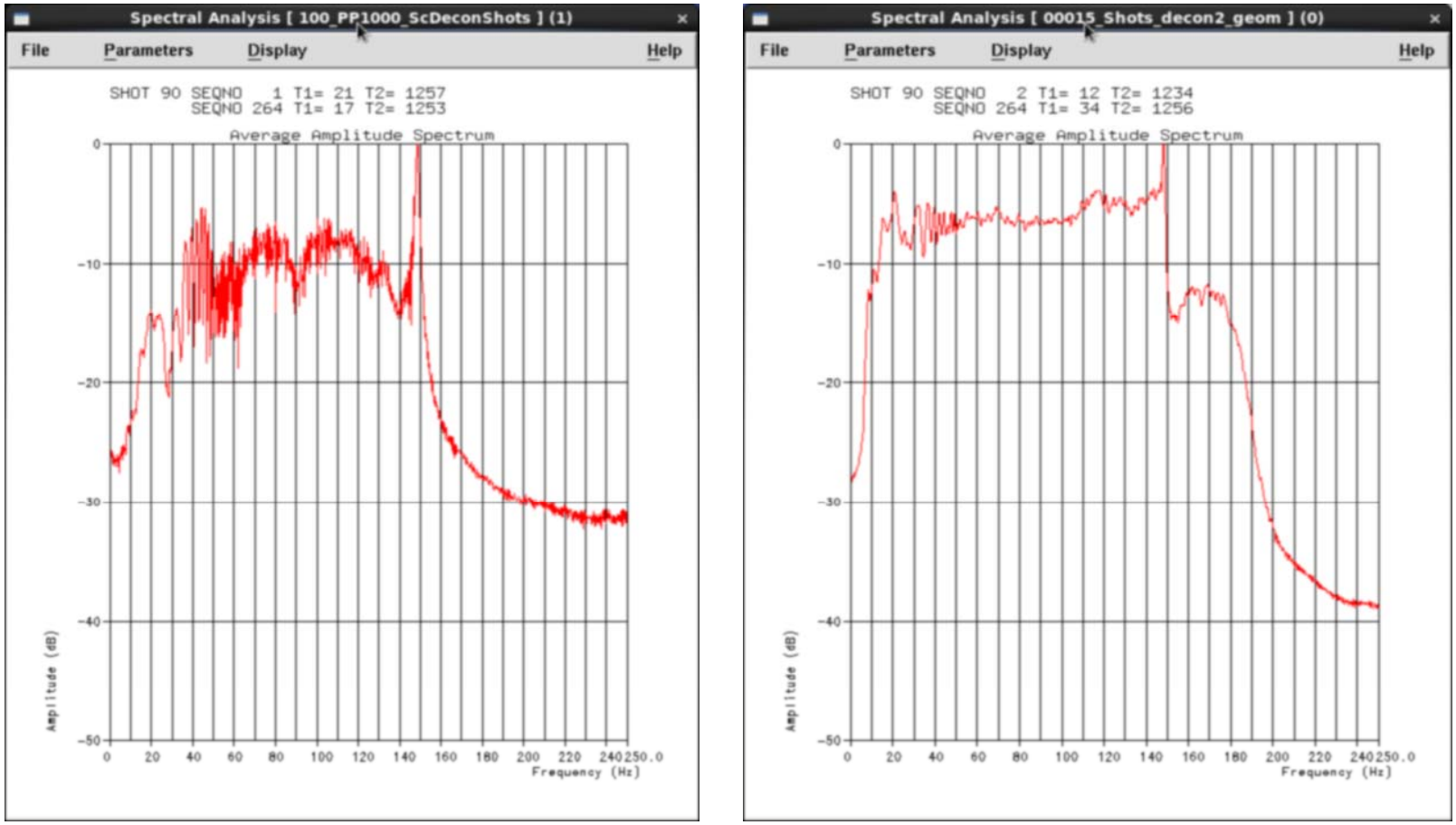

Fig. 4: Spectral analysis (left), SC4Decon PDGM time. (right). Divestco SC5Tdecon - frequency

Surf. Consistent Five comp. decon.. continued

- **Line 2000 – Shot No.91**

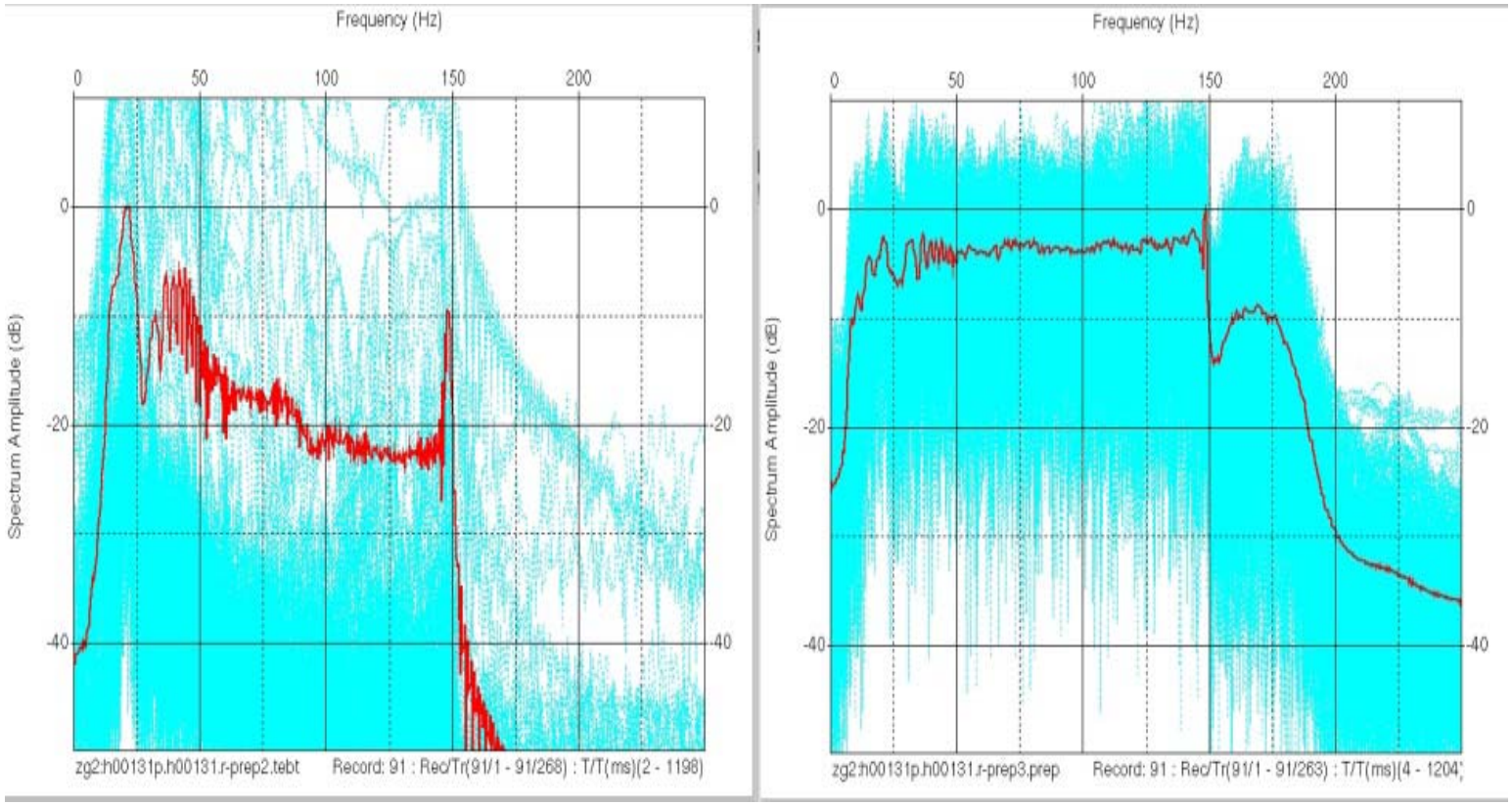

Fig. 5: Spectral analysis for shot 91, Line 2000. Left: Spectral Analysis Before Decon. Right:. Spectral Analysis after Decon using Divestco SC5Tdecon.

S.C. Five component deconvolution…. continued

- **Line 91 – Shot No. 31**

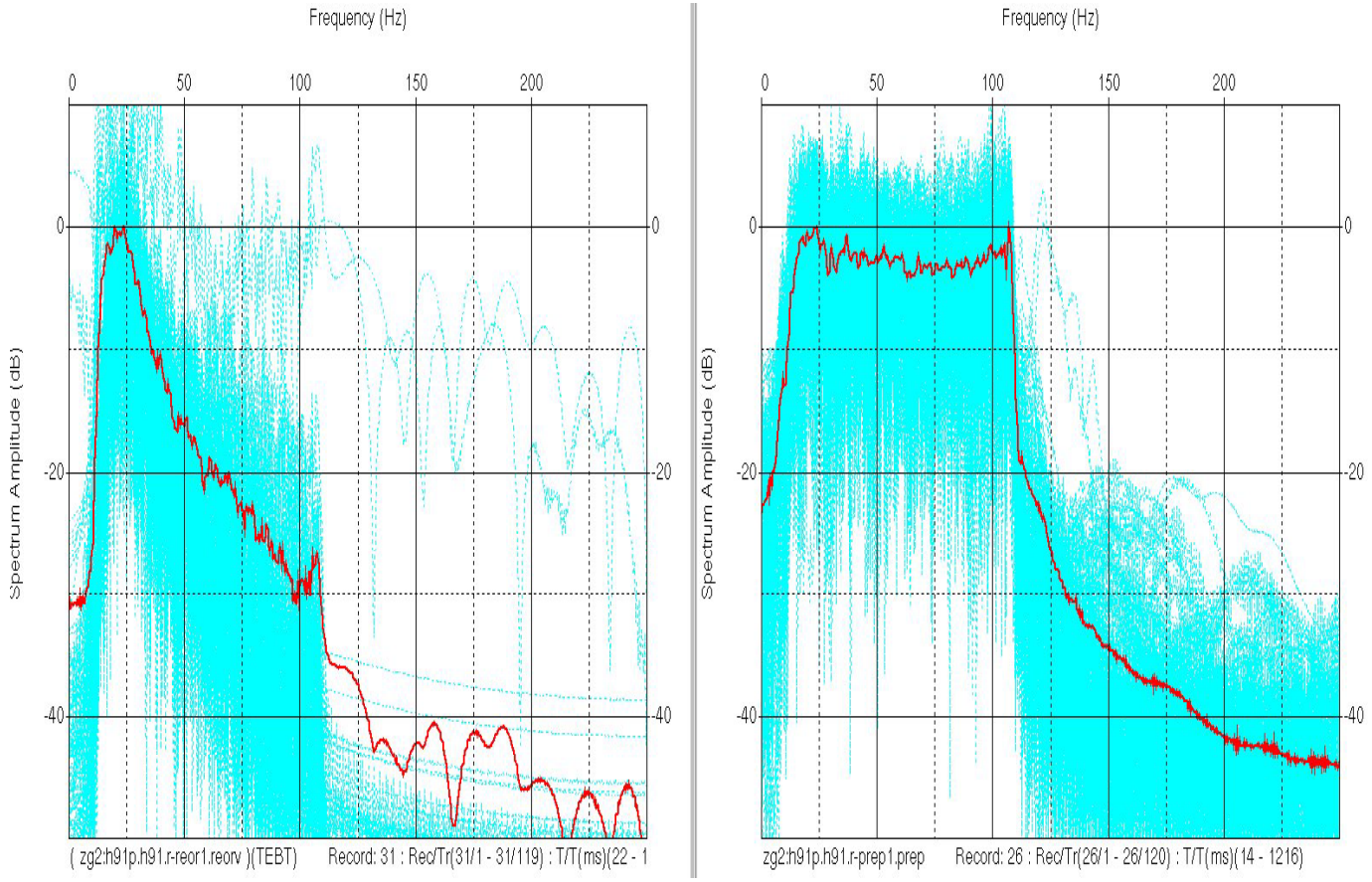

Fig. 6: Spectral analysis for shot 31, Line1991. Left: Spectral Analysis Before Decon. Right:. Spectral Analysis after Decon using Divestco SC5Tdecon.

SCDecon –Shot 54, Line 2000

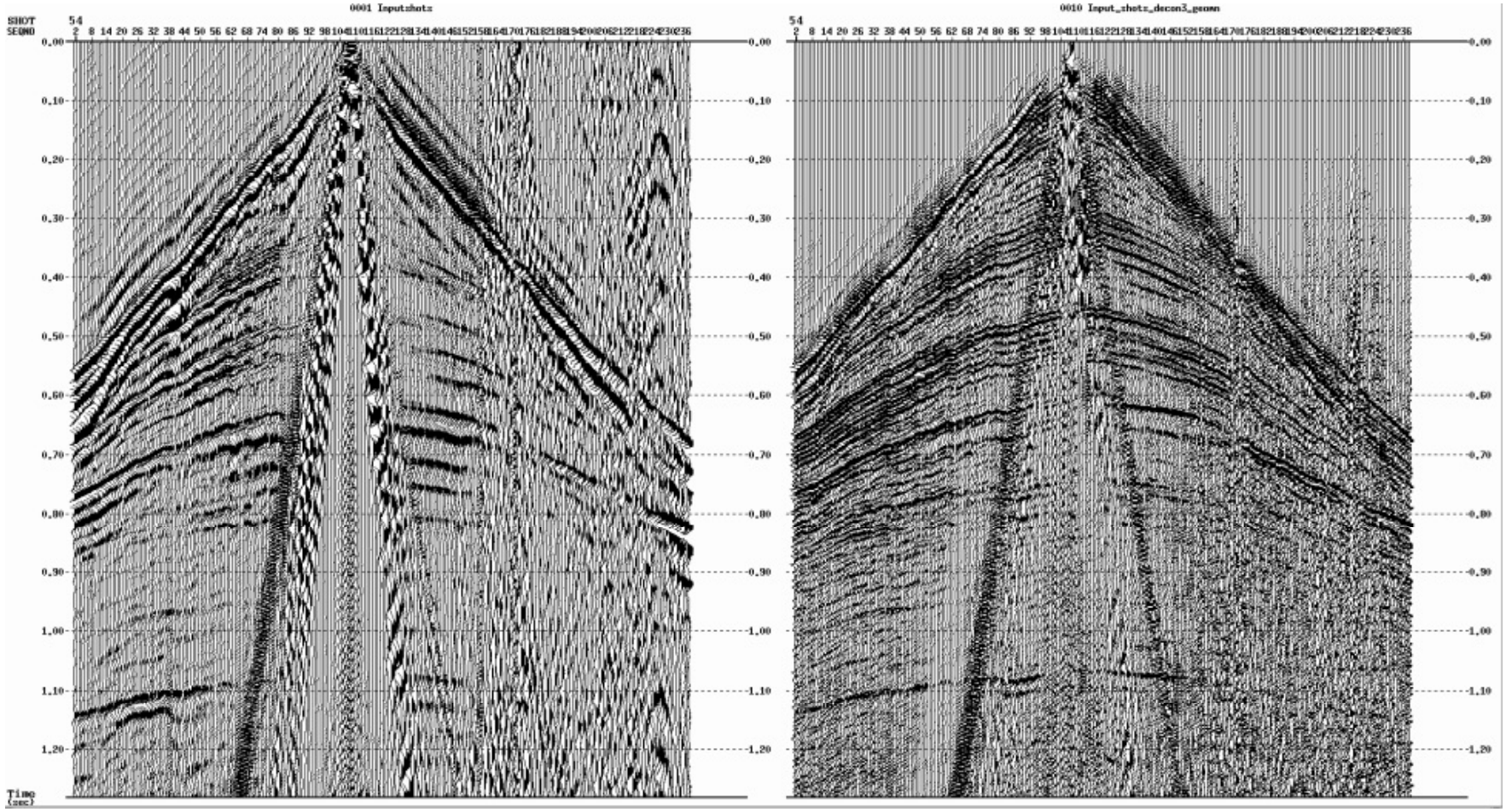

Fig. 7: (left), Original shot. Right: Shot after Divestco SC5Tdecon -frequency

Noise attenuation

- **A procedure where noise can be modeled and then subtracted from original data – resulting in a Noise attenuated shot gather.**

- **Some of ground roll and pump jack noise were also attenuated after Decon.**

- **Noise attenuation procedure applied to line 2000**

Noise attenuation… continued

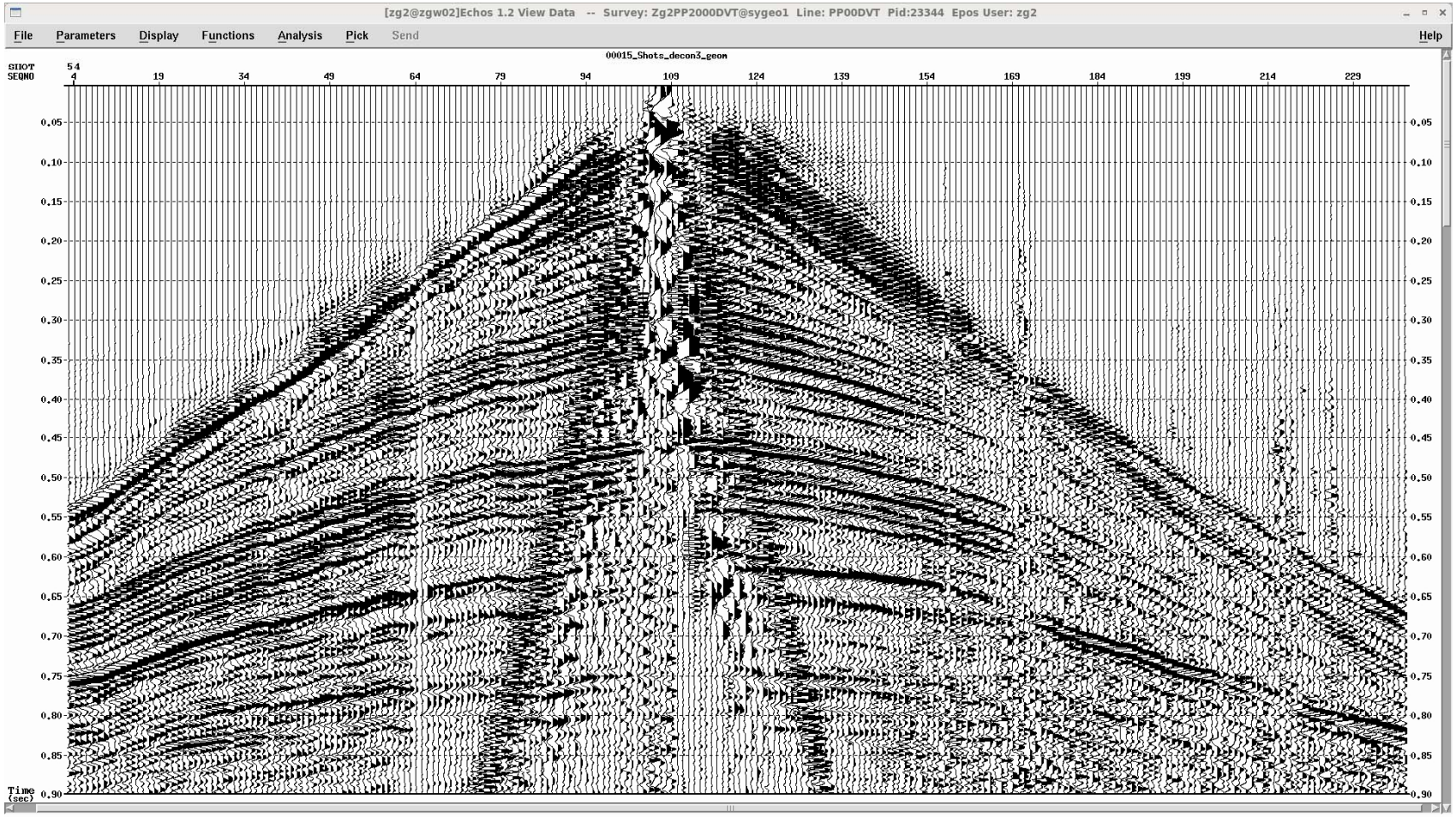

Fig. 8: shot before noise attenuation.

Noise attenuation… continued

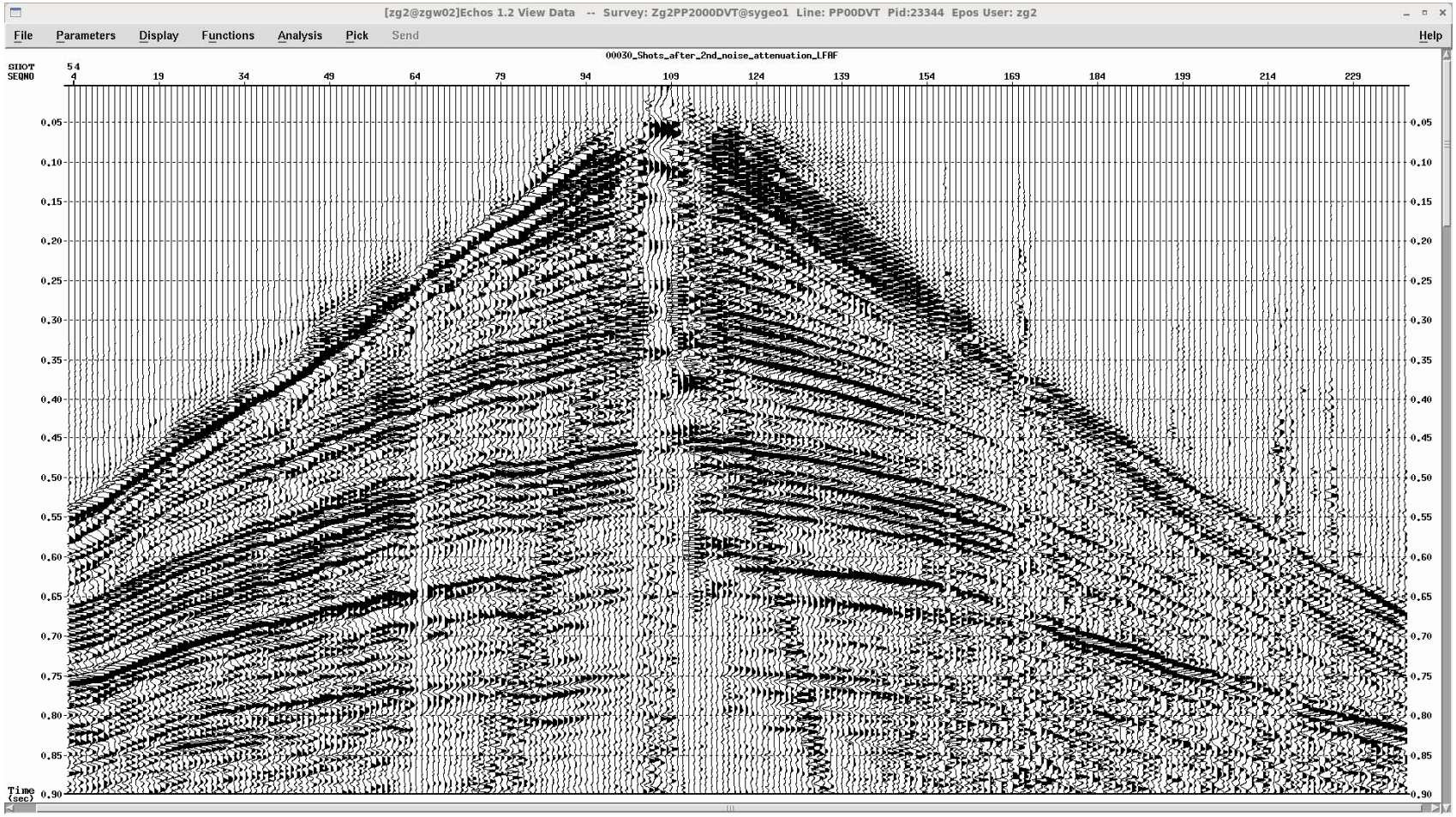

Fig. 9: Shot after noise attenuation

Noise attenuation… Example form 3D survey

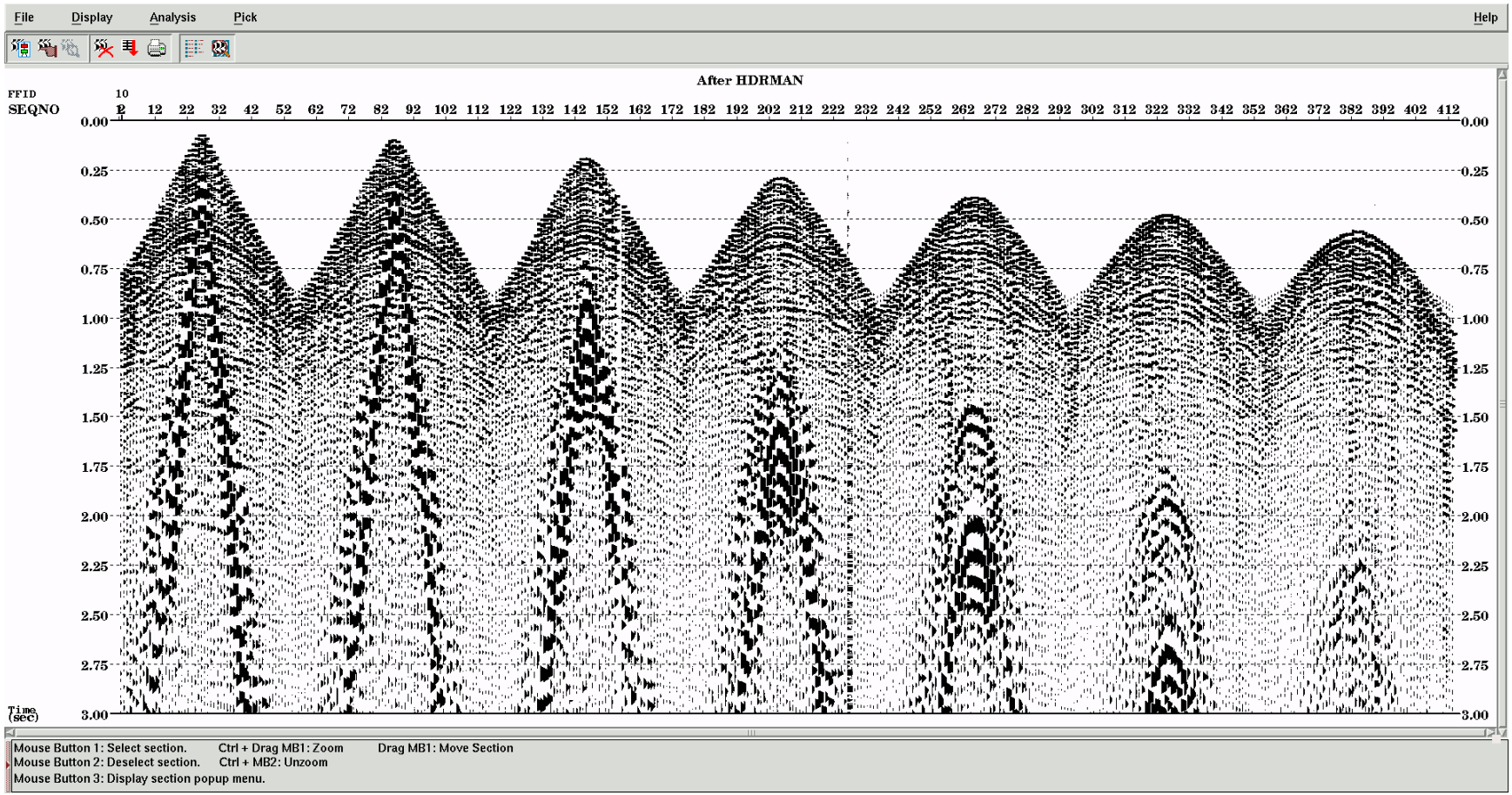

Fig. 10: Shot before noise attenuation

Noise attenuation… Example form 3D survey

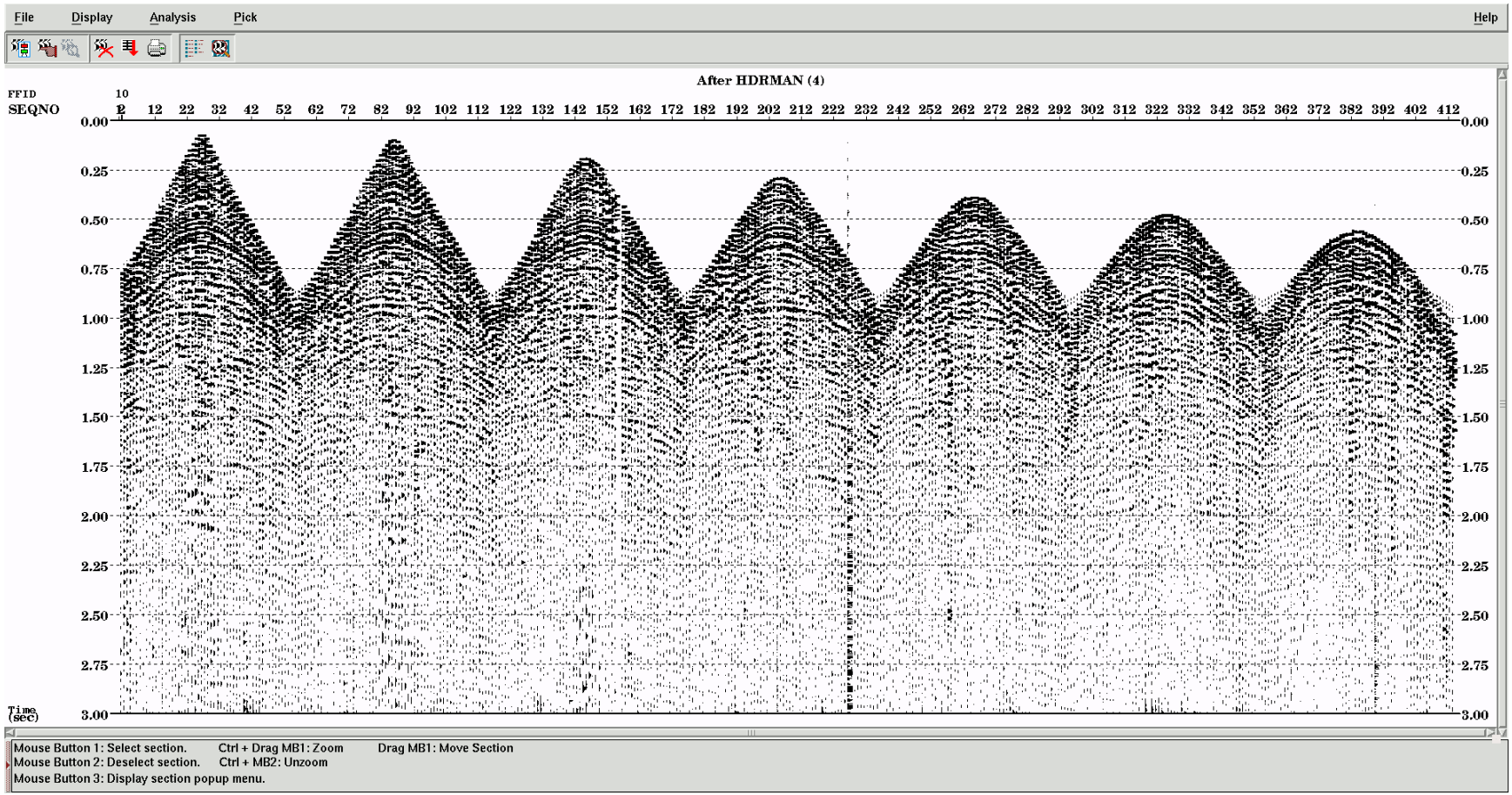

Fig. 11: Shot after noise attenuation

Velocity Analysis – Line 1991

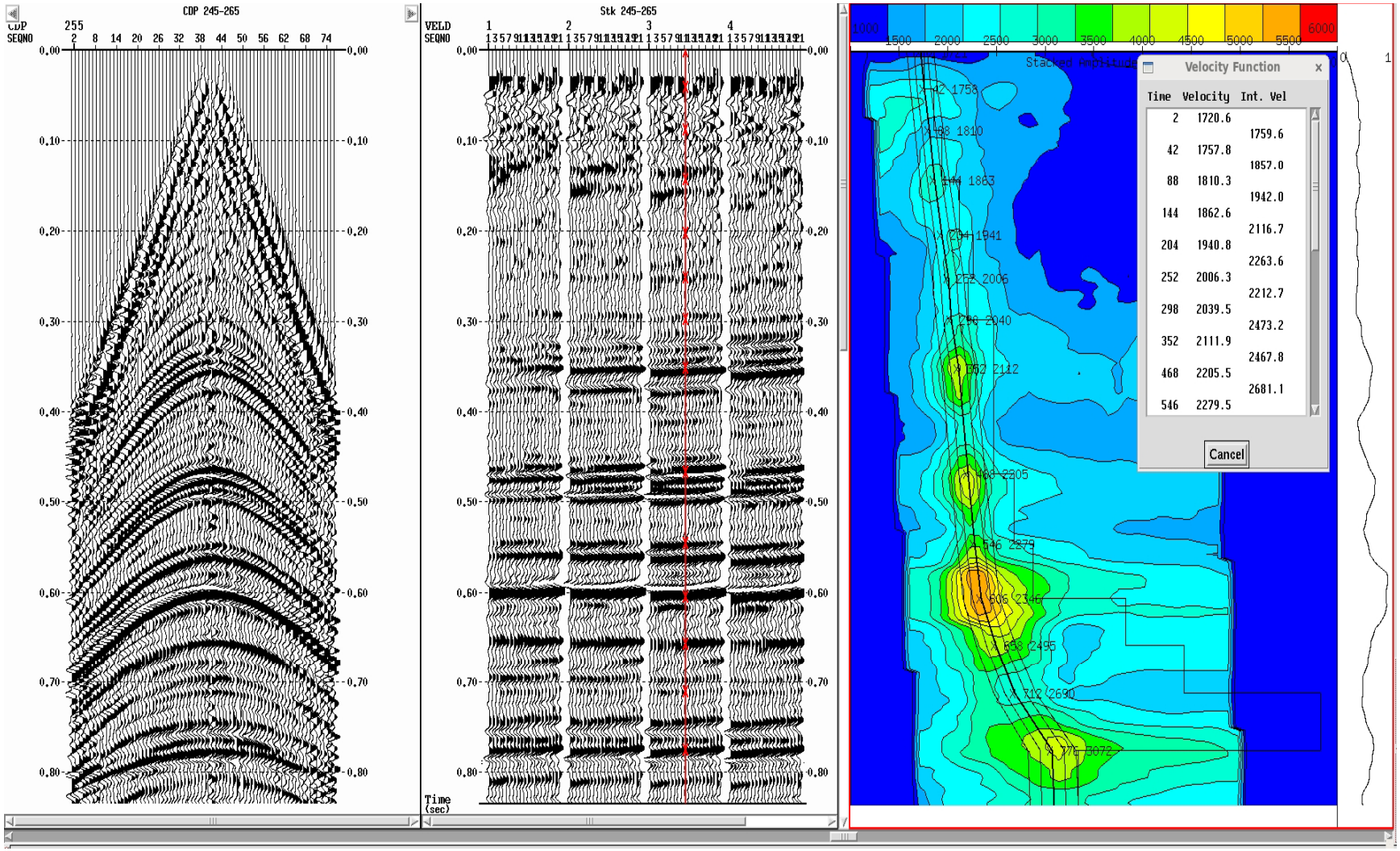

Fig. 12: Second pass of velocity analysis for Line 1991

Velocity Analysis – Line 2000

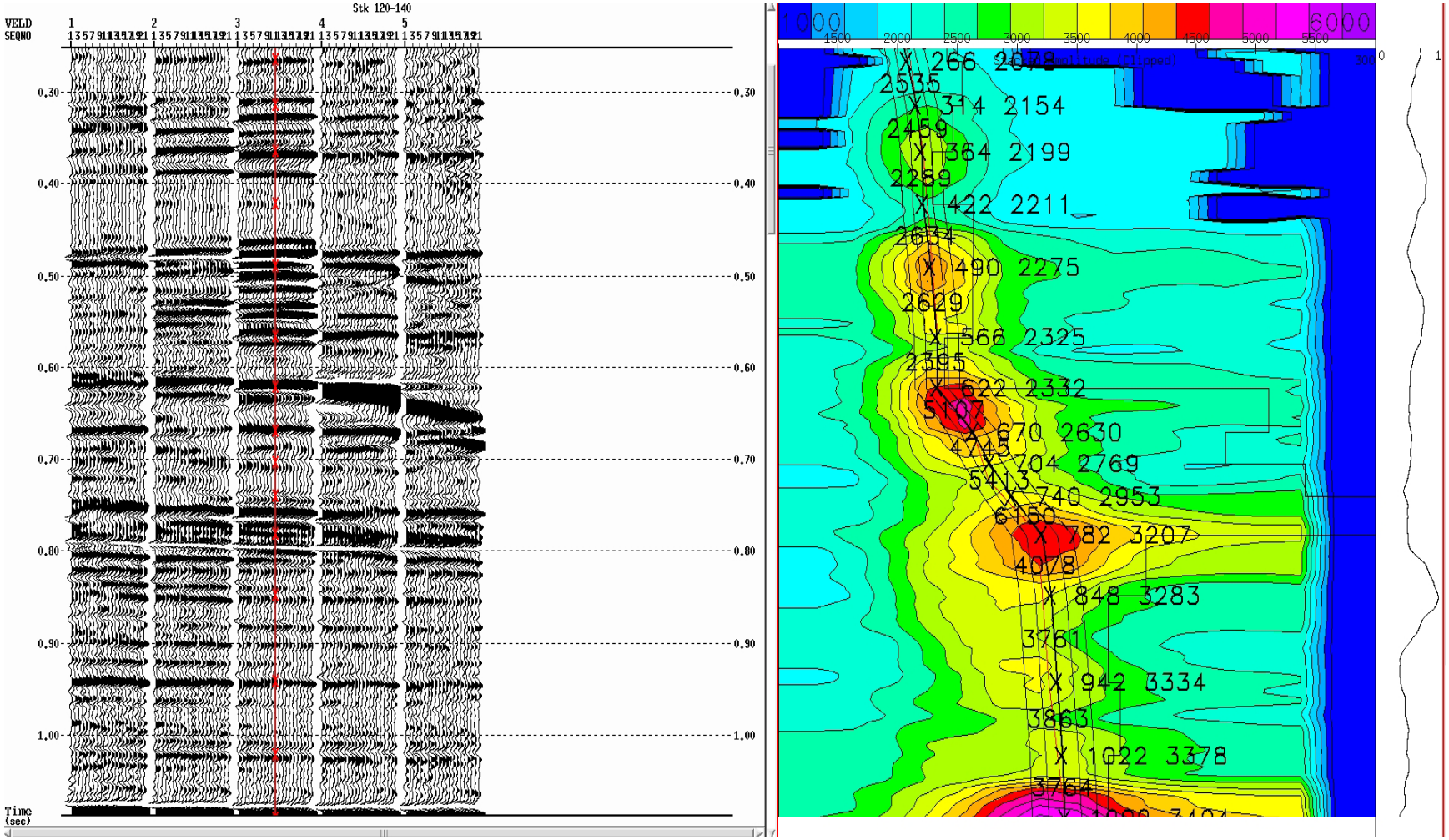

Fig. 13: Second pass of velocity analysis for Line 2000

PSPI Migration

- **Phase Shift Plus Interpolation 1-way 90-degree wave equation downward extrapolation migration method (Gazdag, 1981, 1983).**
- **Exact solution for v(z) and good for v(x,z) model.**
- **Frequency bandwidth (5-170Hz)**
- **Padding: 640m each side, time padding 20% of trace length.**

- **Extras: Excitation time imaging condition replacing the downgoing wave of the source (Ng, 1994); essentially time shift imaging condition to interpolate in between ‘depth’ steps (Ng, 2007, 2008, 2009).**

Structure Stack Vs. PSPI– Line 91

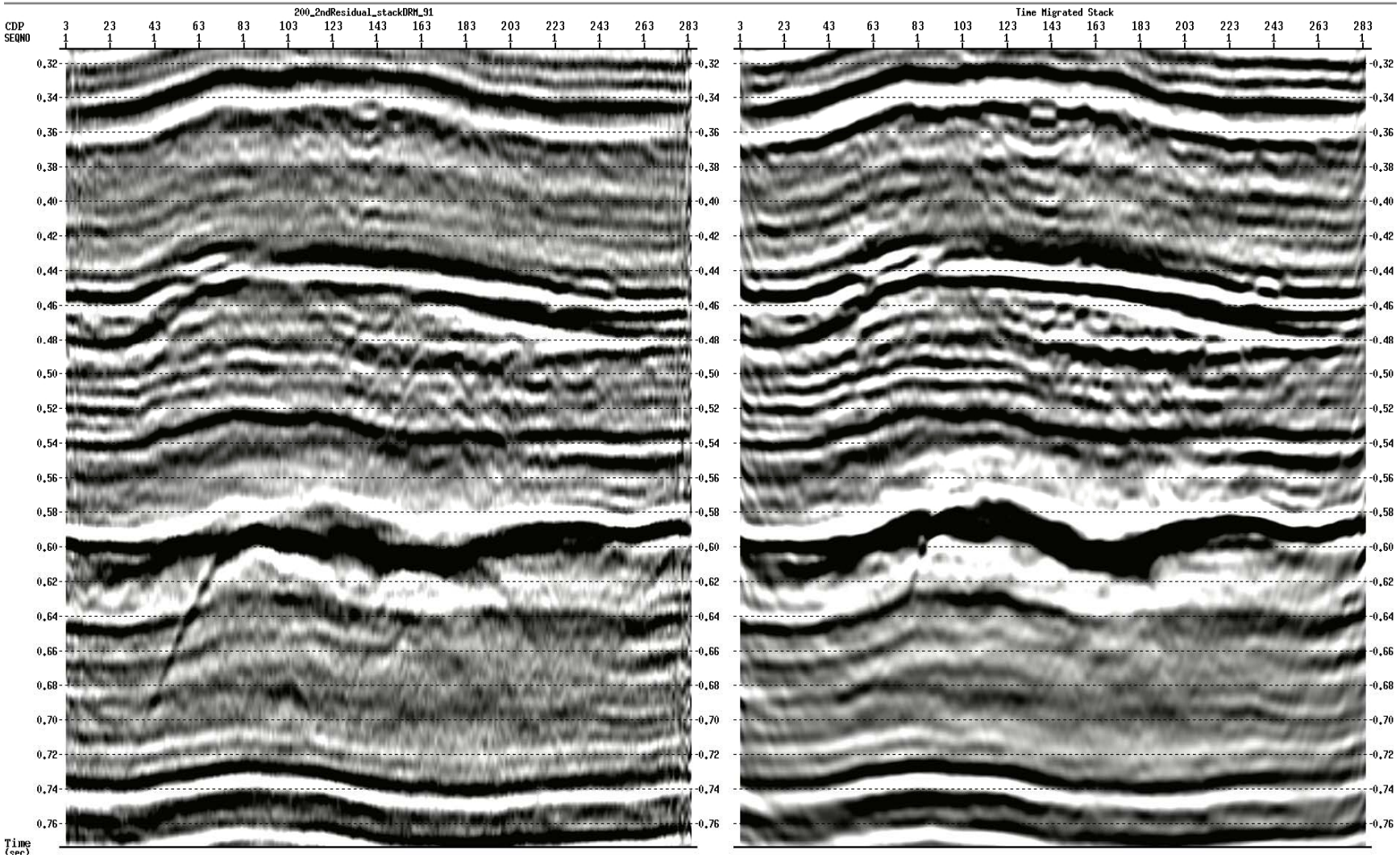

Fig. 14: Left: Structure stack. Right: PSPI migrated for Line 1991

Structure Stack Vs. PSPI– Line 91…. color

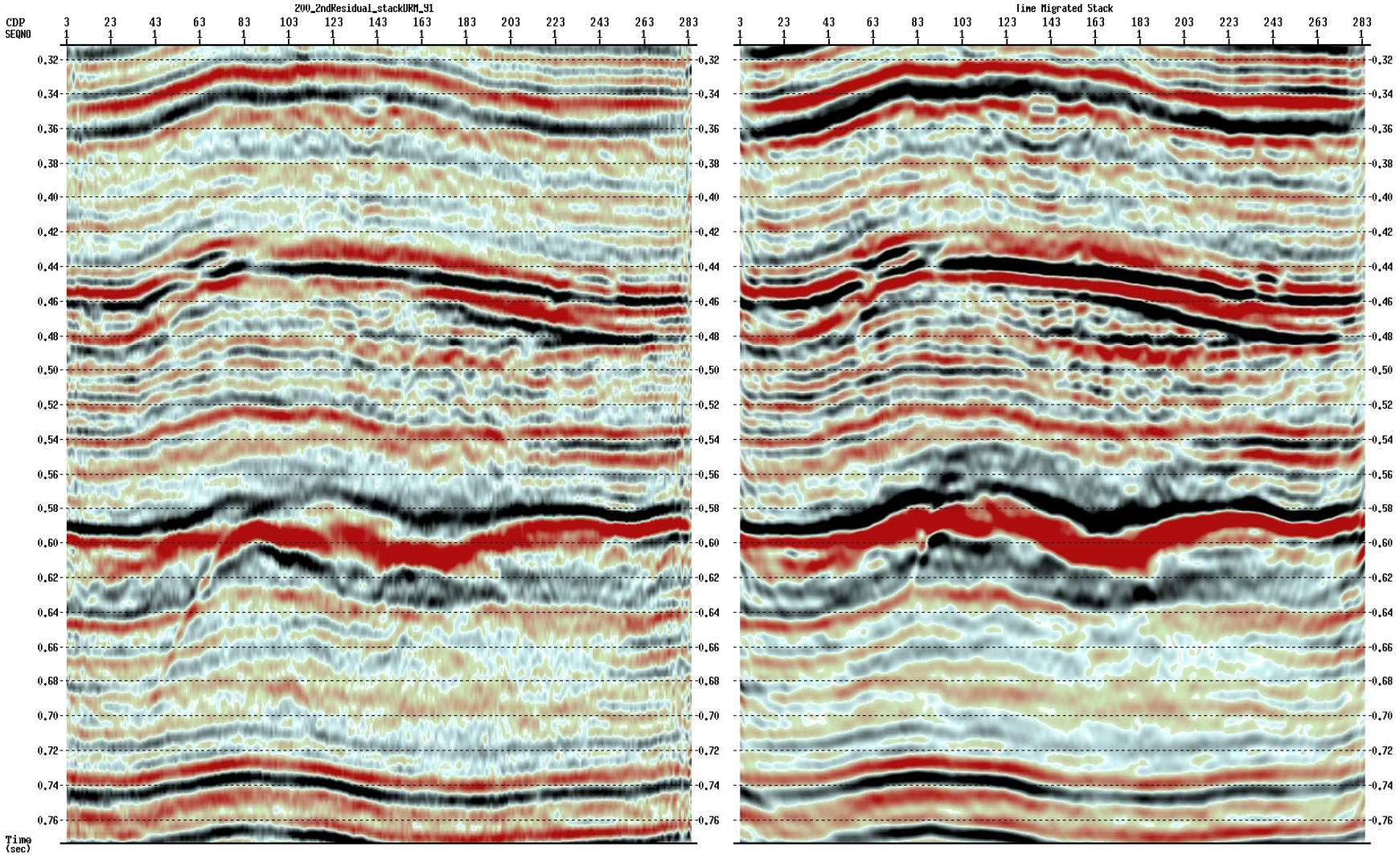

Fig. 15: Left: Structure stack. Right: PSPI migrated for Line 1991 – color scale

Structure Stack Vs. PSPI– Line 2000

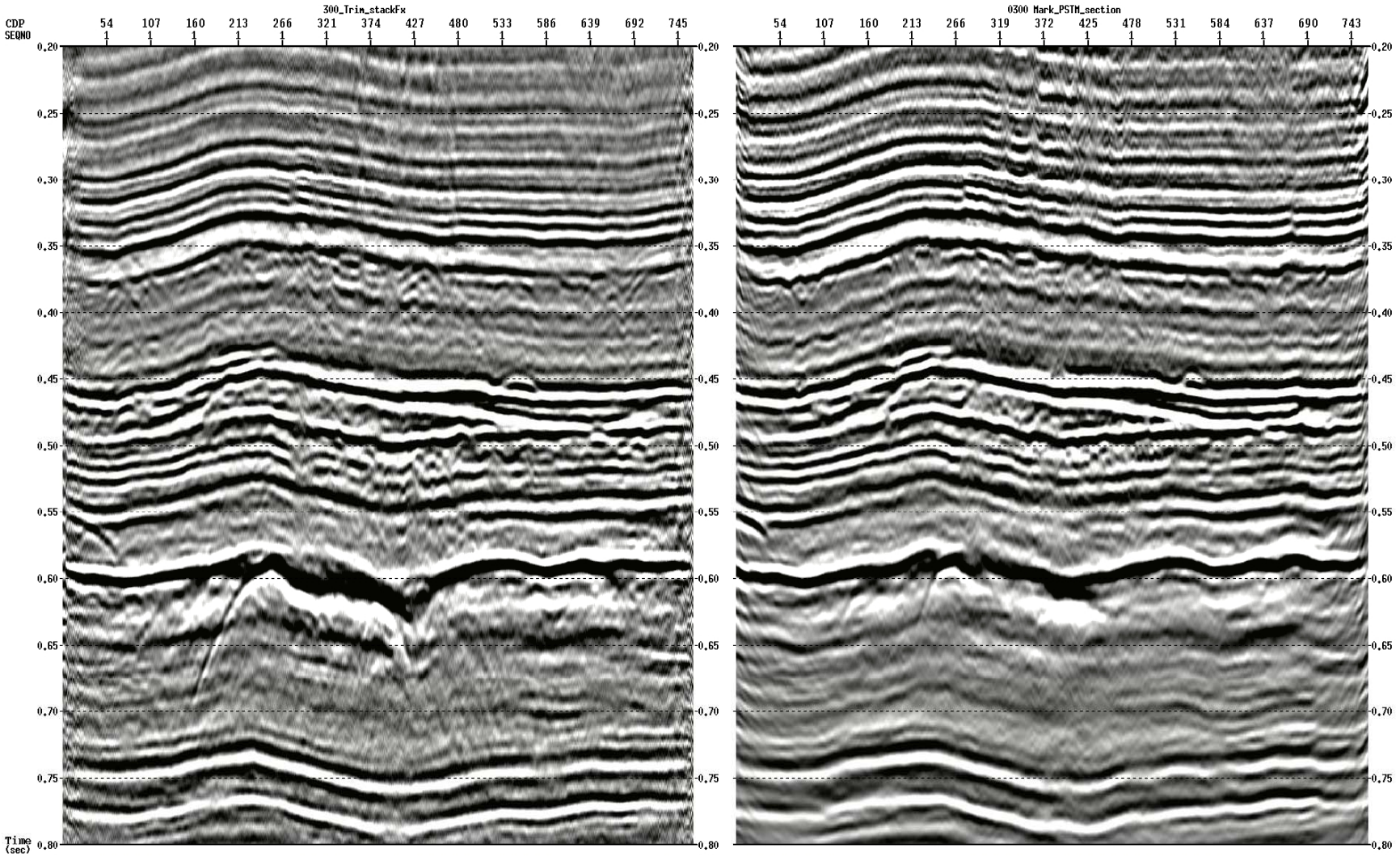

Fig. 15: Left: Structure stack. Right: PSPI migrated for Line 2000

Structure Stack Vs. PSPI– Line 2000 … color

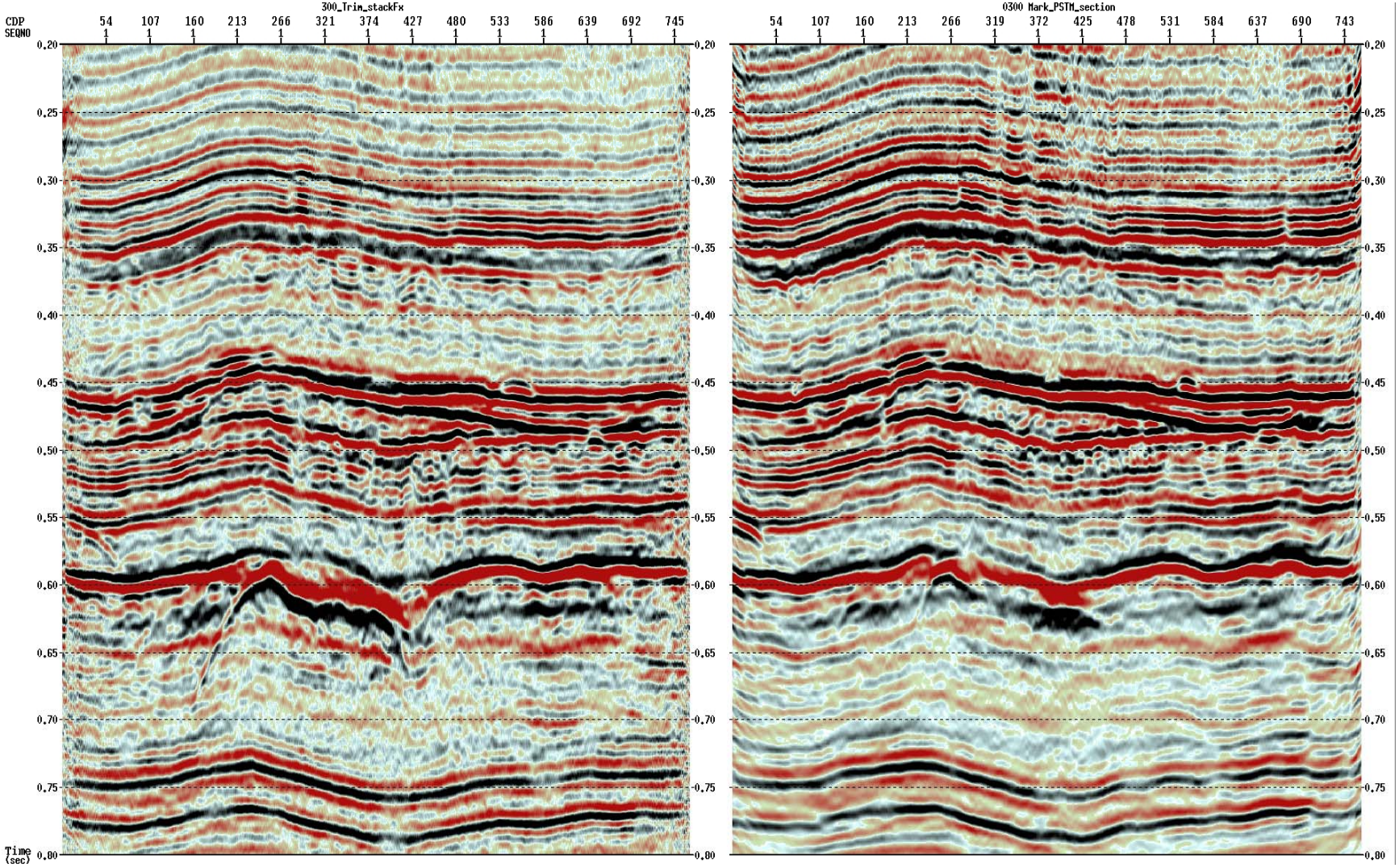

Fig. 15: Left: Structure stack. Right: PSPI migrated for Line 2000

Conclusions

- **SC. deconvolution in Frequency domain maintain frequency bandwidth compared to SC. Deconvolution in time domain.**
- **Noise attenuation by modeling proved to be effective tool in removing noise while preserving reflectivity amplitudes.**
- **PSPI migration provides successful imaging for Waseca channel reservoir, and collapsed diffraction along UPC zone.**

Acknowledgments

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