Color correction for Gabor deconvolution: a test with field data

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CREWES

Background

White reflectivity assumption of deconvolution

- Distortion of relative amplitude
- Phase rotation

Outline

- color correction for Gabor decon.
- test with field data
- Conclusions

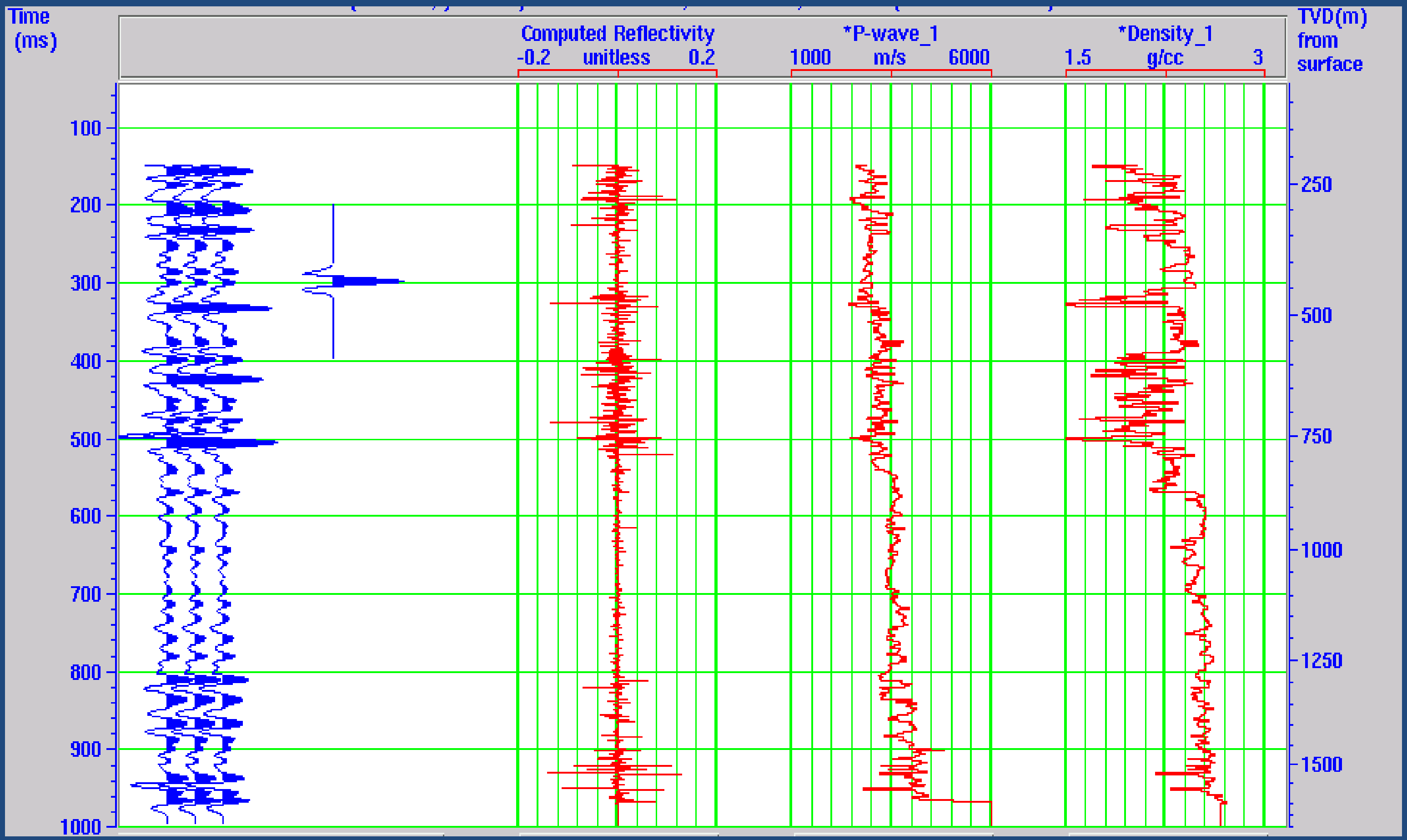
Color correction for Gabor decon.

- Nonwhite reflectivity in practice

$$r_c(t) \rightarrow |R'_G(\tau, f)| \neq 1$$

That is, even when smoothed, the Gabor spectrum of the reflectivity is not constant. Instead it shows a general time and frequency dependence which we call " temporal color" and "spectral color respectively.

Nonwhite reflectivity from well 14-09



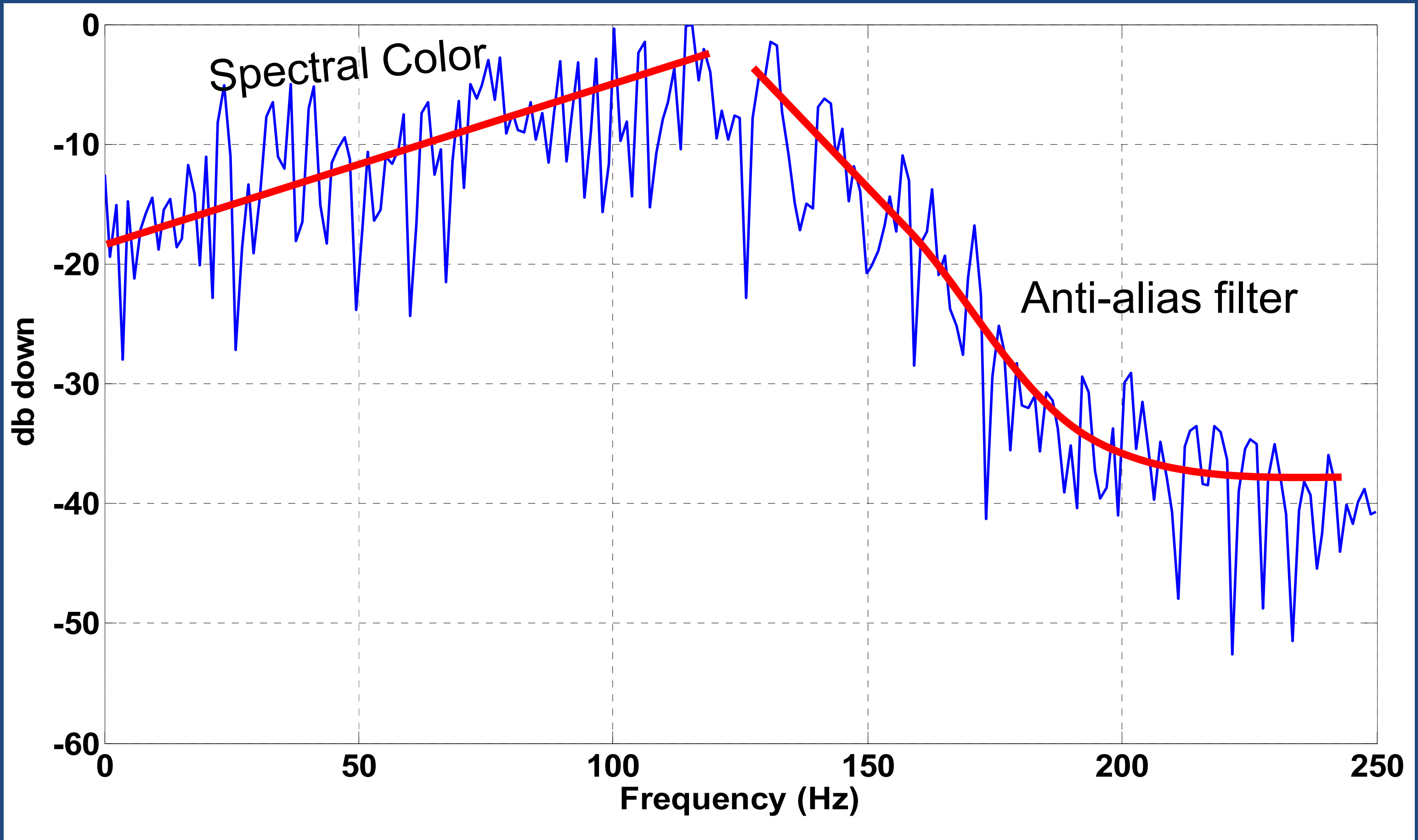
Synthetic seismic trace

Computed reflectivity

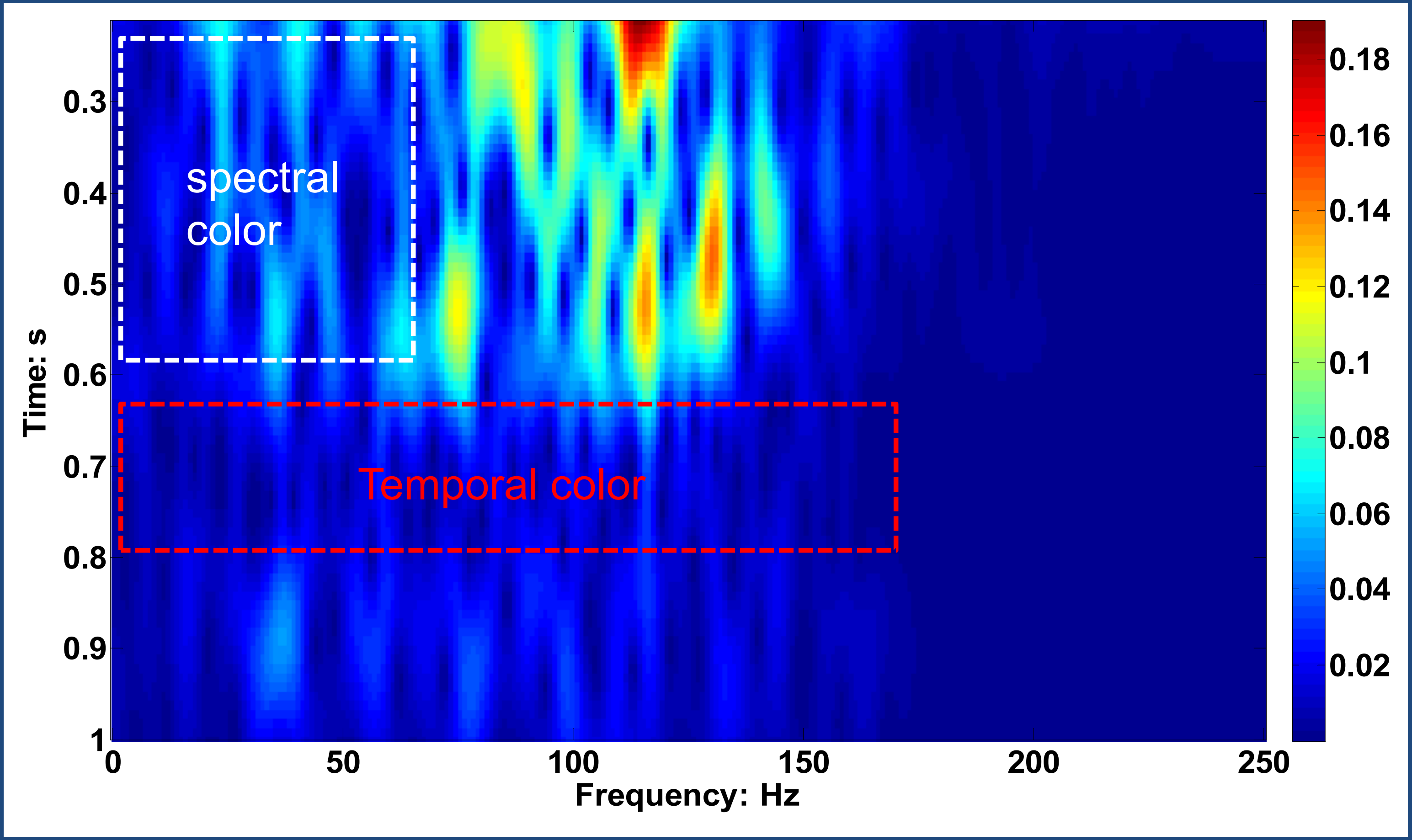
P-wave velocity

Density

Nonwhite reflectivity in Fourier domain



Nonwhite reflectivity in the Gabor domain



Color correction for Gabor decon.

- Condition: The smoothed Gabor spectrum $\overline{\left|R'_G(\tau,f)\right|}$ of true reflectivity can be obtained from well log data.
- Estimation of nonwhite reflectivity

$$R'_G(\tau,f)_{est}=\frac{S_G(\tau,f)\overline{\left|R'_G(\tau,f)\right|}}{\overline{\left|S_G(\tau,f)\right|}+\mu A_{\max}}e^{i\varphi_c(\tau,f)}$$

$$\varphi_c(\tau,f)=H\left(\ln\left|\frac{\overline{R'_G(\tau,f)}}{\overline{S_G(\tau,f)}+\mu A_{\max}}\right|\right)$$

Practical color correction

- Approximation of time-variant reflectivity color

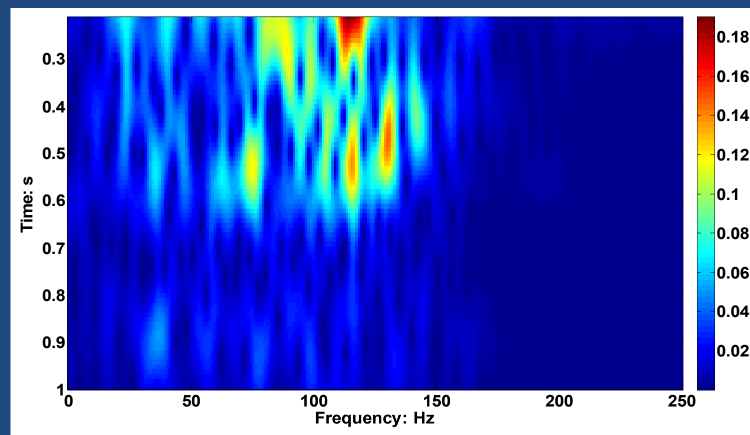
$$\tilde{r}_c(t) \to \tilde{R}_G(\tau, f)$$

$$|\tilde{R}_G(\tau, f)| \approx a'_0(\tau) + a'_1(\tau) f + a'_2(\tau) f^2 \qquad \tau \in [t_1, t_2]$$

$$\overline{|R'_G(\tau, f)|} = a_0(\tau) + a_1(\tau) f + a_2(\tau) f^2 \qquad \tau \in [0, t_{\max}]$$

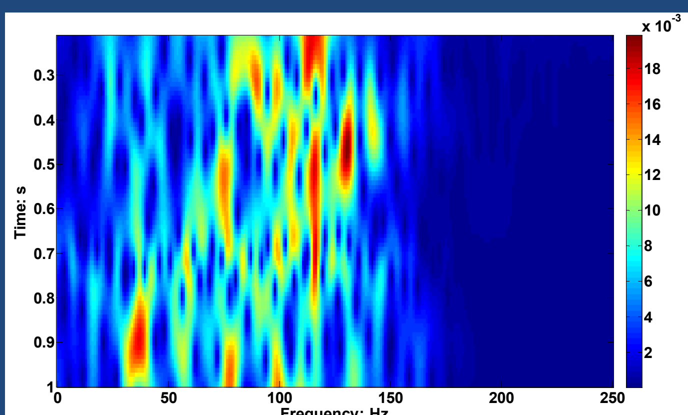
$$a_i(\tau) = \begin{cases} a'_i(t_1), 0 \le \tau \le t_1 \\ a'_i(\tau), t_1 < \tau < t_2 \quad i = 1,2,3 \\ a'_i(t_2), t_2 \le \tau \le t_{\max} \end{cases}$$

Decomposition of reflectivity color for field data processing

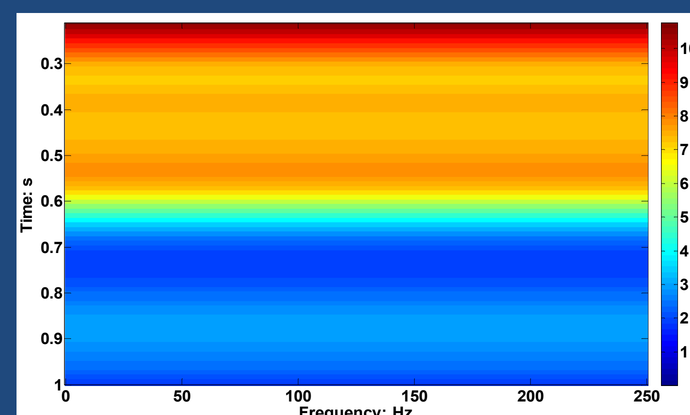


Full color

=



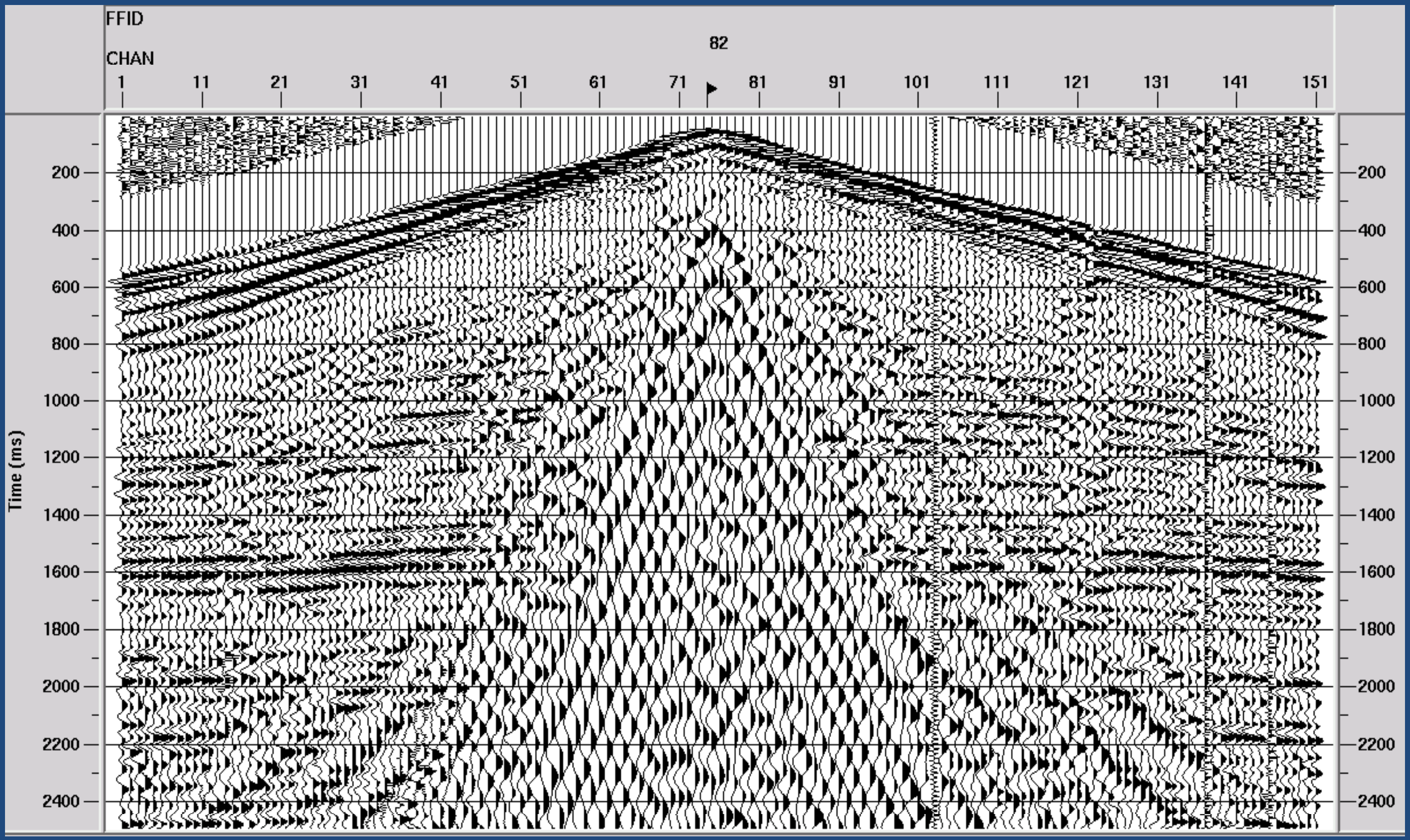
X



Spectral color

Temporal color

Blackfoot field data



Blackfoot 1995: 159 shot stations,151 receiver stations

Processing of field data using ProMax

- job flow

  Statics correction, decon,. NMO, stacking, decon., kirchhoff time migration

- Decon. schemes

  1) Gabor decon.

     prestack & poststack decon: Gabor decon

  2) Spectral color correction

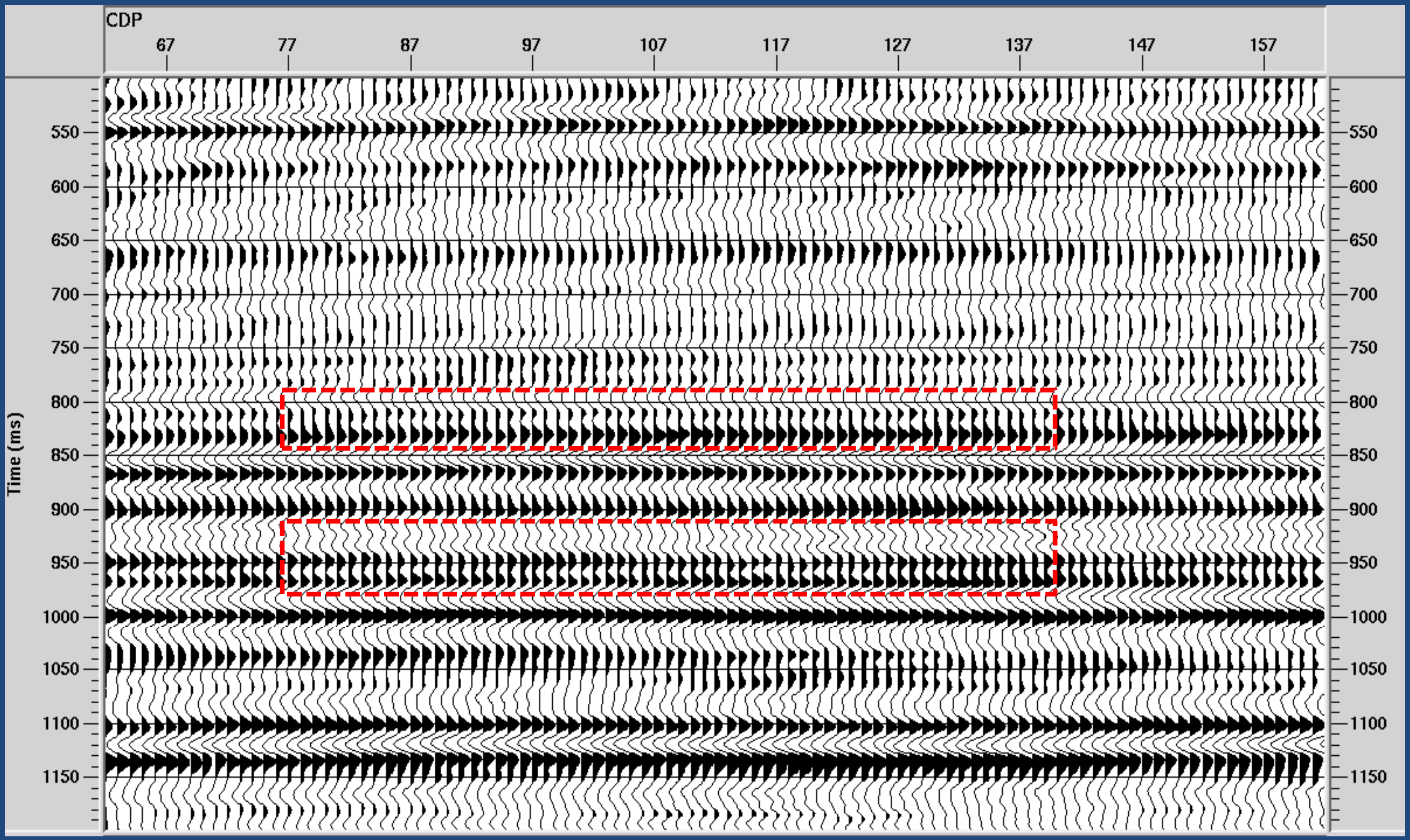
     prestack & poststack decon: spectral color correction

  3) full color correction

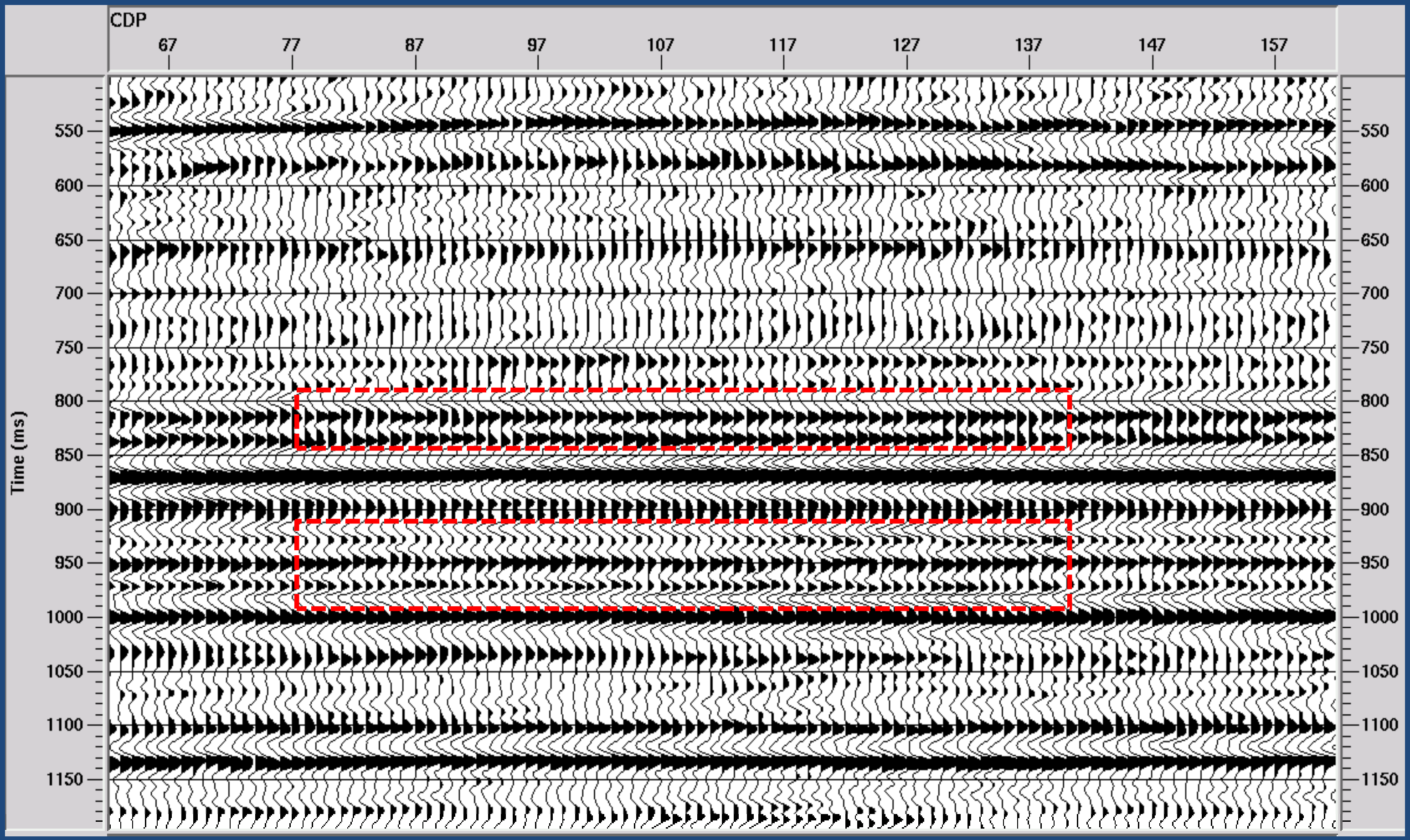
     prestack decon: spectral color correction

     poststack decon: full color correction

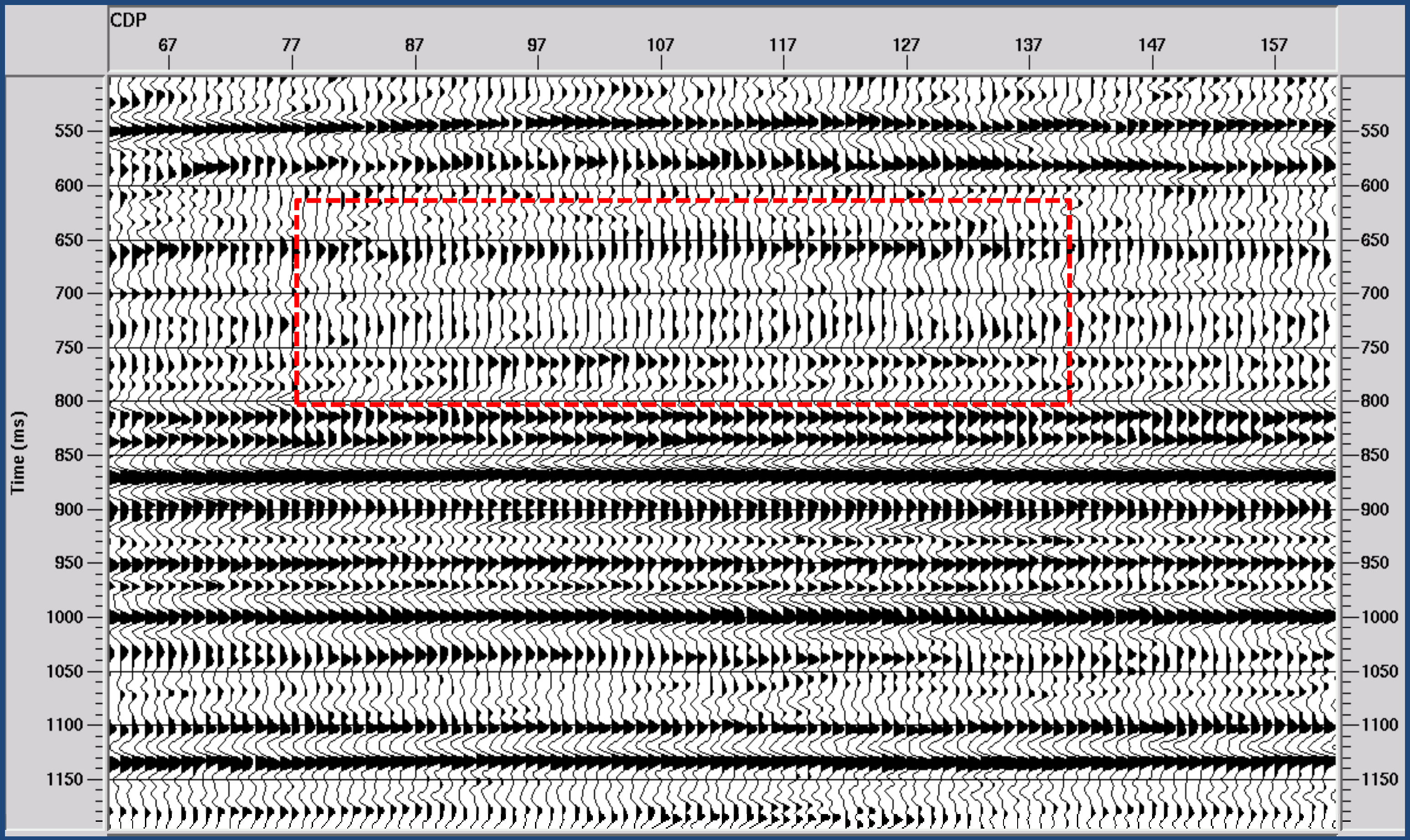
Zoomed migrated data with Gabor decon.



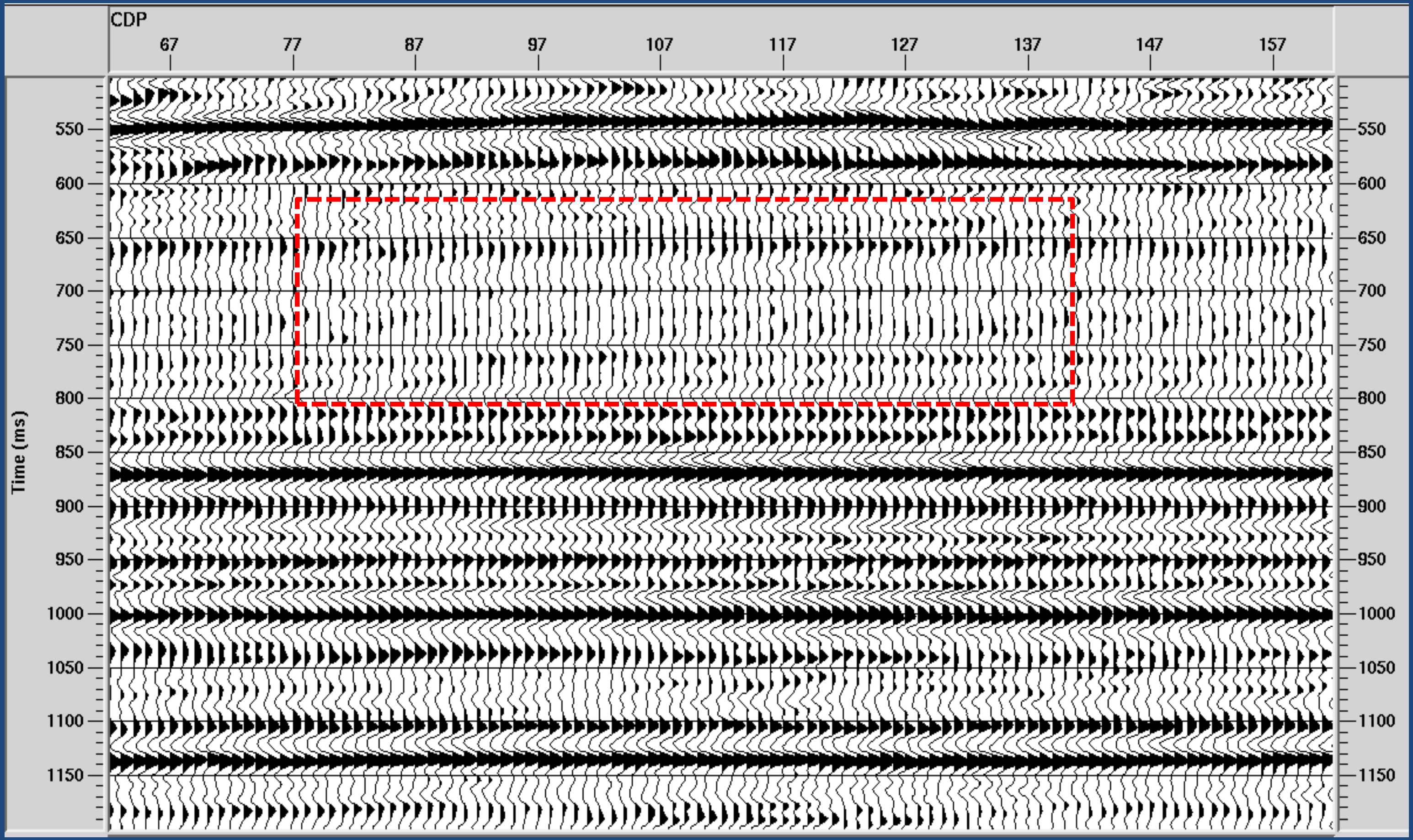
Zoomed migrated data with spectral color correction



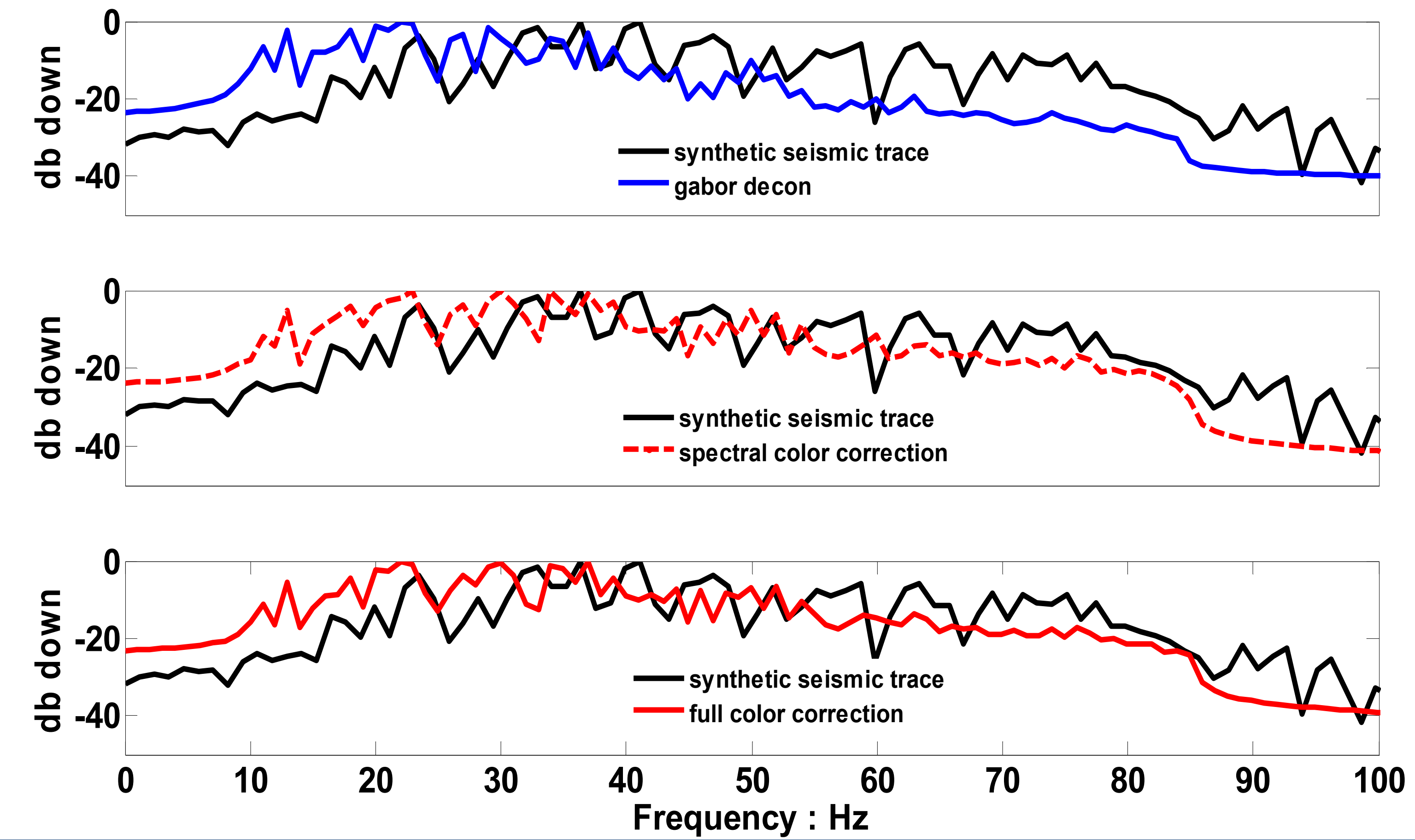
Zoomed migrated data with spectral color correction



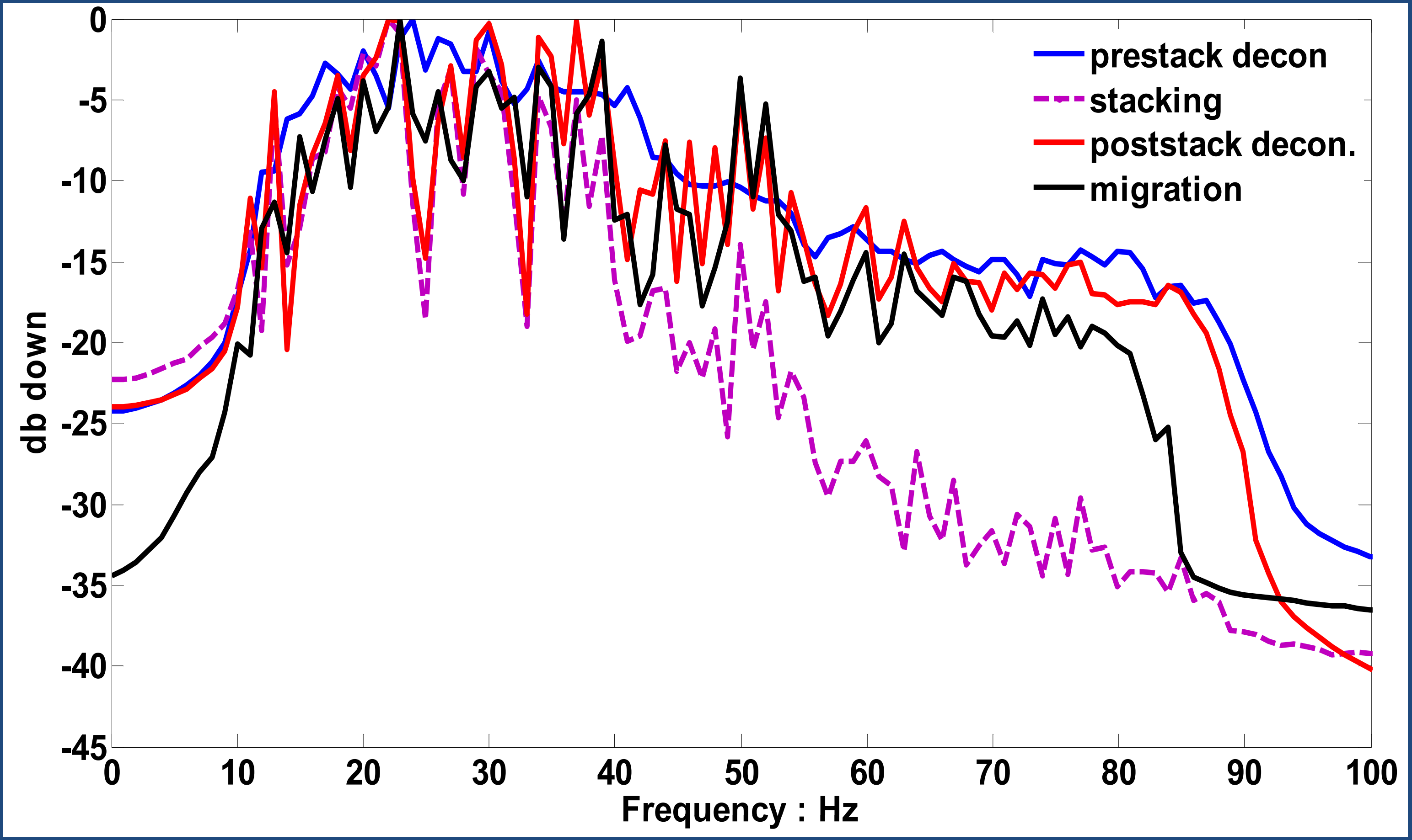
Zoomed migrated data with full color correction



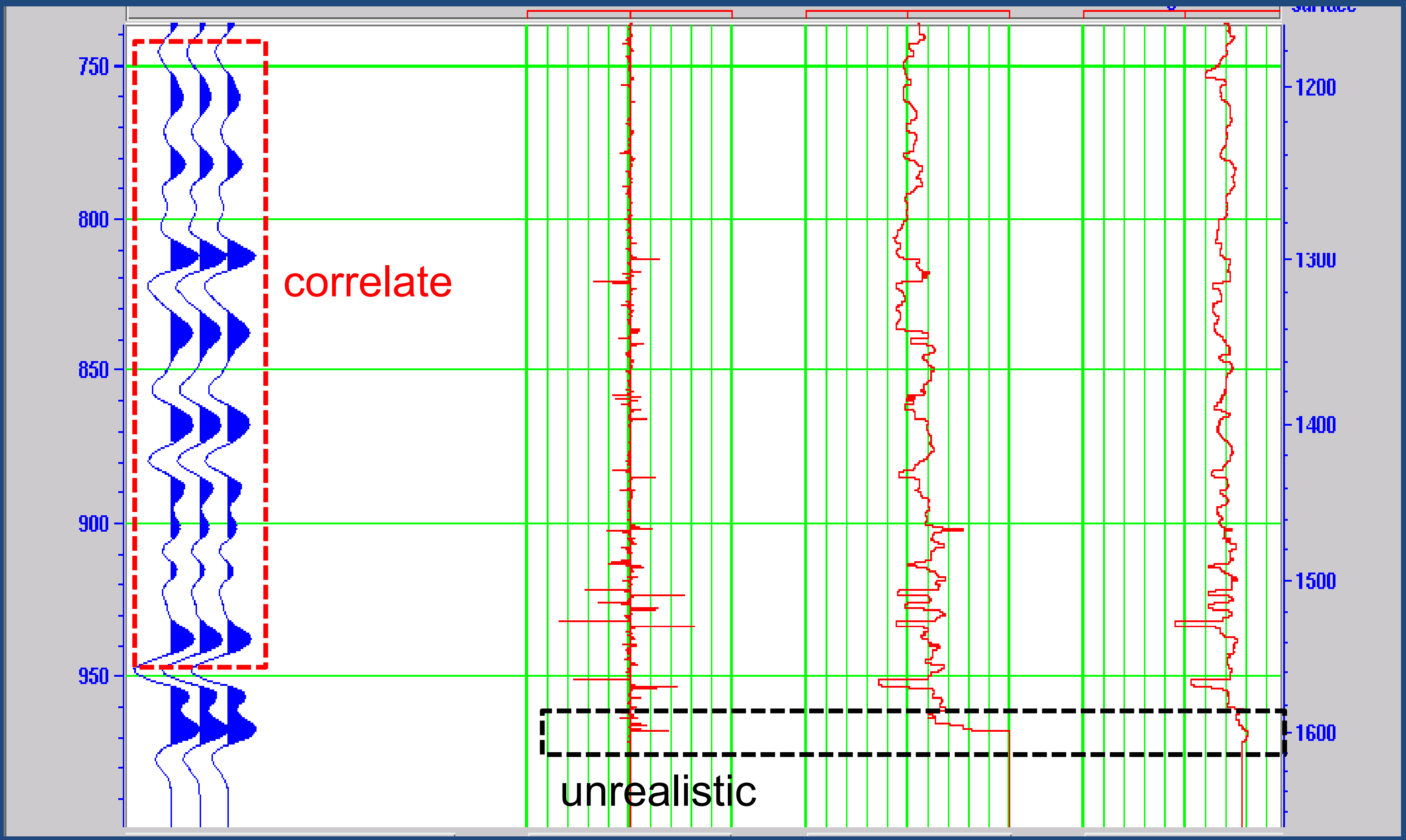
Average amplitude spectra of migrated data



Average amplitude spectra of seismic data at different stage of data processing flow



Zoomed well log 14-09 for correlation



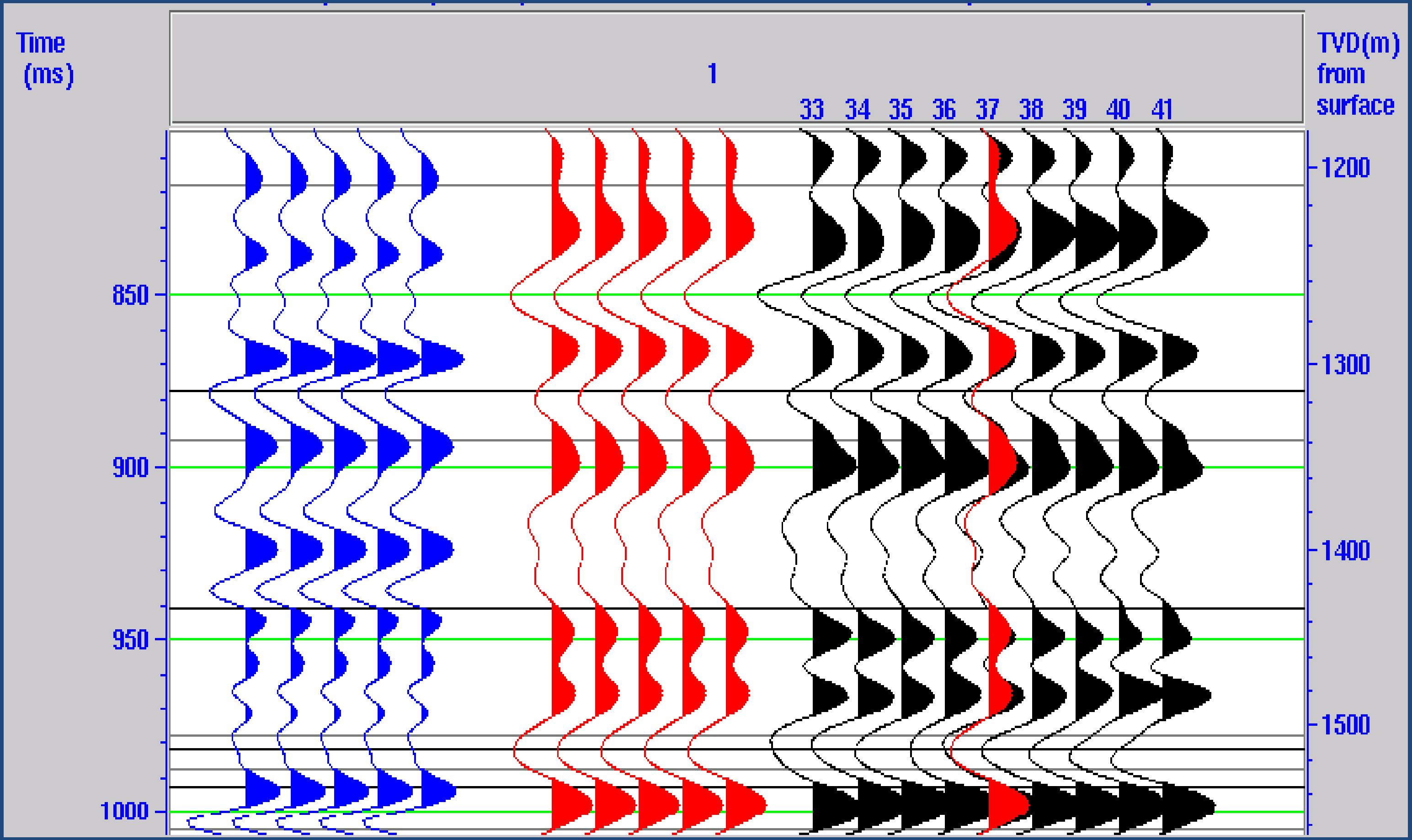
Synthetic seismic trace

Computed reflectivity

P-wave velocity

Density

Correlation of synthetic trace and migrated seismic data with Gabor decon

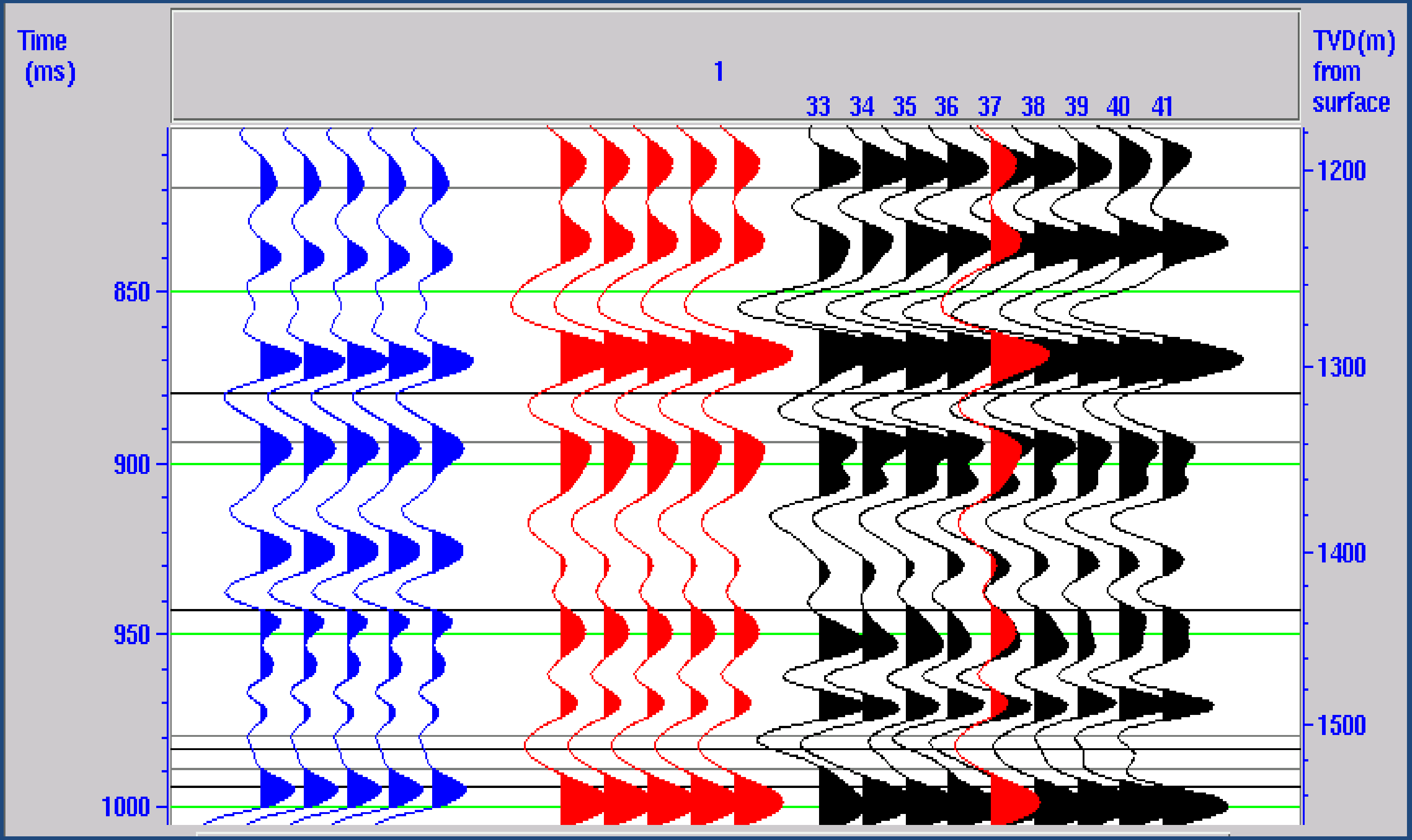


Synthetic seismic trace

Migrated seismic trace: CDP 37

Migrated seismic traces: CDP 33 - 41

Correlation of synthetic trace and migrated seismic data with spectral color correction

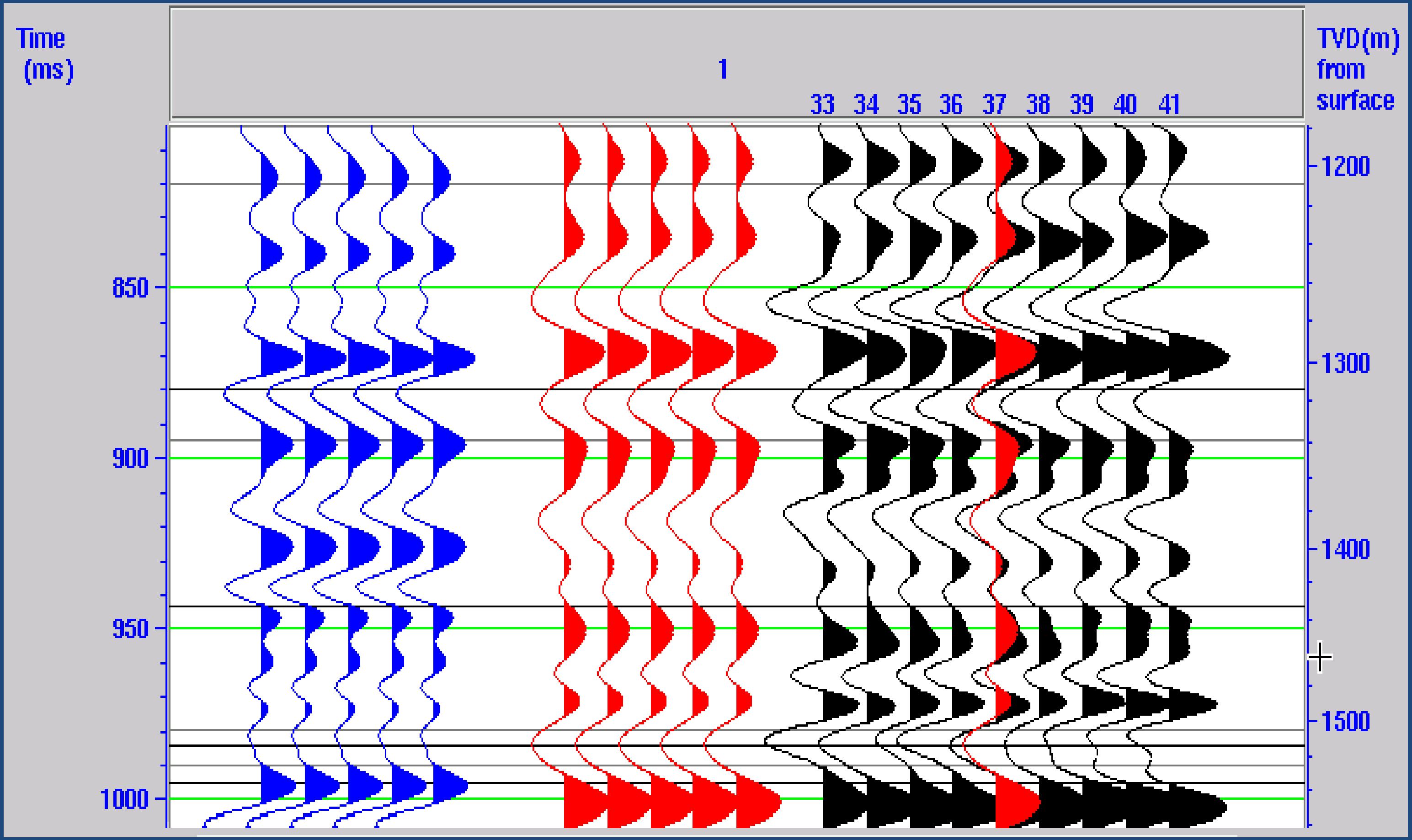


Synthetic seismic trace

Migrated seismic trace: CDP 37

Migrated seismic traces: CDP 33 - 41

Correlation of synthetic trace and migrated seismic data with full color correction

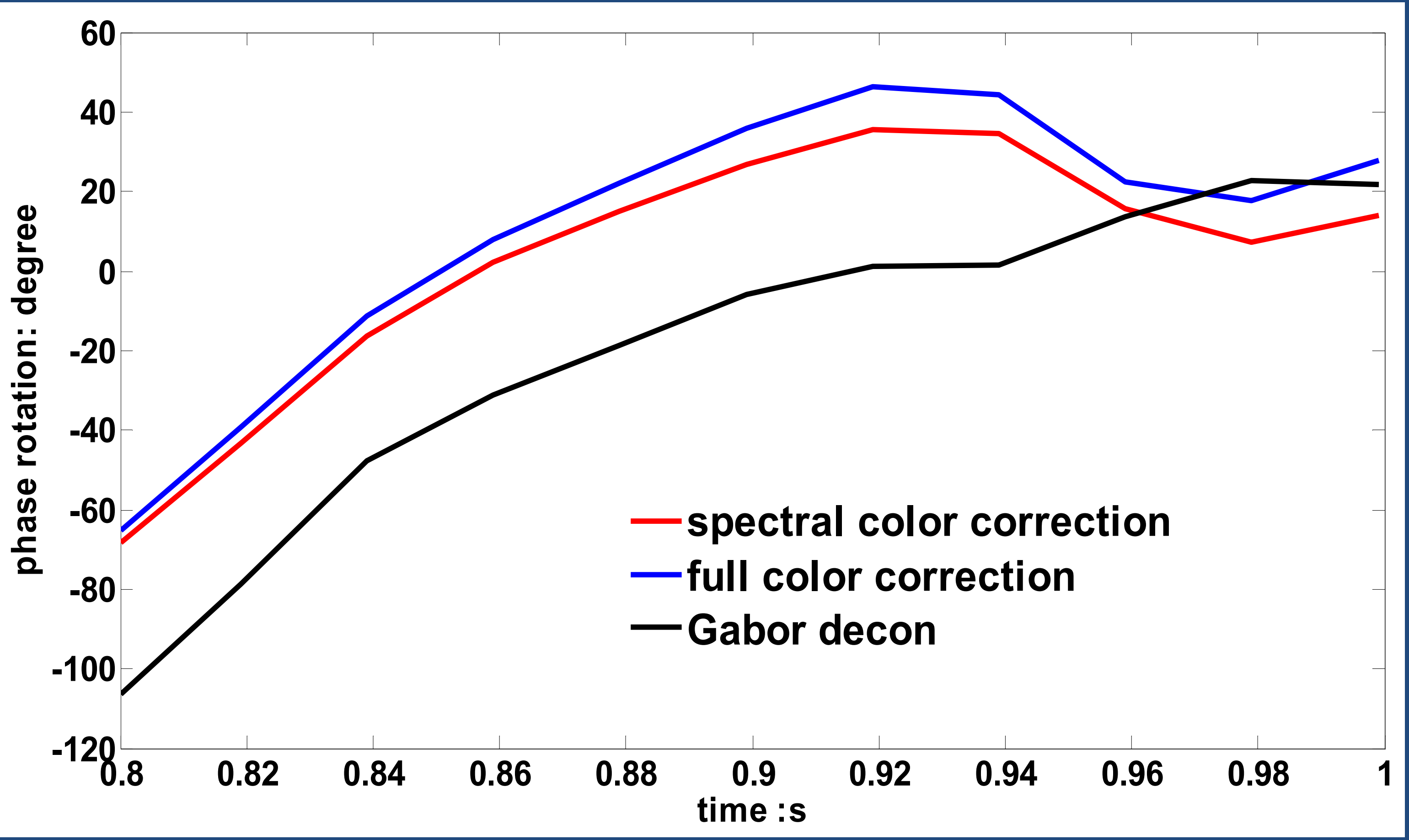


Synthetic seismic trace

Migrated seismic trace: CDP 37

Migrated seismic traces: CDP 33 - 41

Phase rotation between migrated seismic trace and synthetic seismic trace



Conclusions

- Real reflectivity is not white and usually has both spectral color and temporal color.

- Spectral color correction can be applied to shot records directly.

- Color correction can improve the resolution of seismic data, and obtain a better tie to well log data.

- Deconvolution can whiten the spectrum of seismic data, while stacking and Kirchhoff time migration de-whiten the spectrum of seismic data at different levels.

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Thank you!