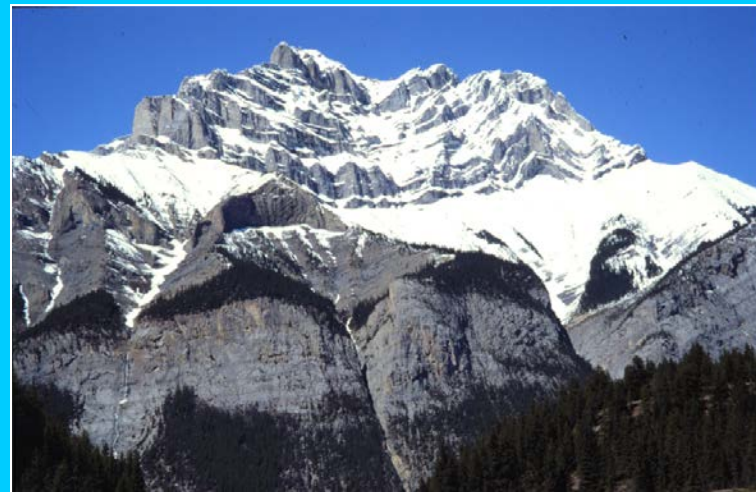

Cascaded Deconvolution Filters

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- November 30, 2017

CREWES

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Exact Deconvolution Filters

Few seismic wavelets will have exact inverse filters for deconvolution.

An exception is the damped exponential sinusoid which has an exact 3-term inverse filter as shown in *"Digital filtering with the second moment norm"* (Lines and Treitel, 1983).

Exact Deconvolution Filters

The wavelet has the form:

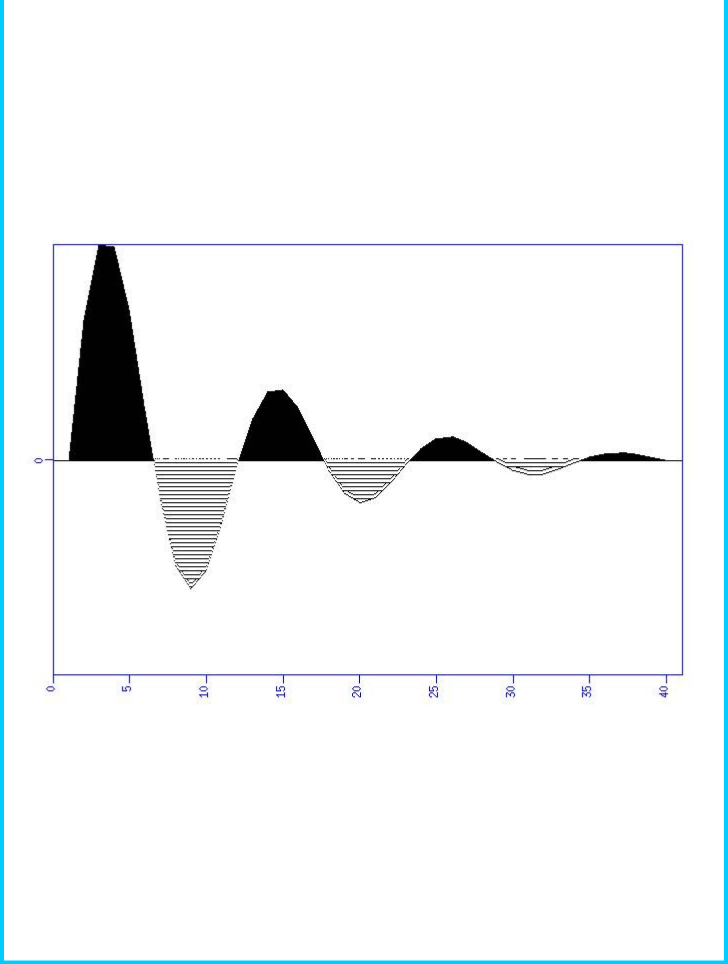
$$w(t) = e^{-\alpha t}\,\mathbf{sin}\,\omega_0 t, \quad \alpha \geq 0, \quad t \geq 0$$

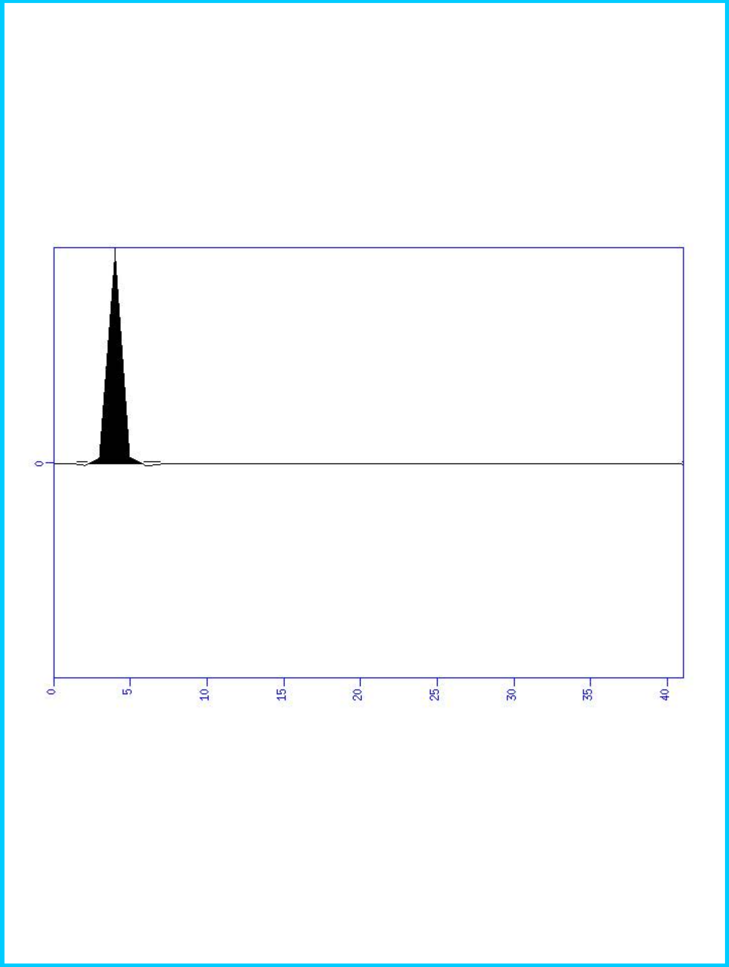
The exact deconvolution filter for the wavelet is the three-term sequence:

$$f(t) = (f_0, f_1, f_2) = \frac{e^{\alpha}}{\sin \omega_0}\left[1, \; -2e^{-\alpha}\cos\omega_0, \; e^{-2\alpha}\right]$$

As shown in (Lines and Treitel, 1983).

Deconvolution of exponentially damped sinusoid (left) where with exact spiking filter produces the output spike (right).



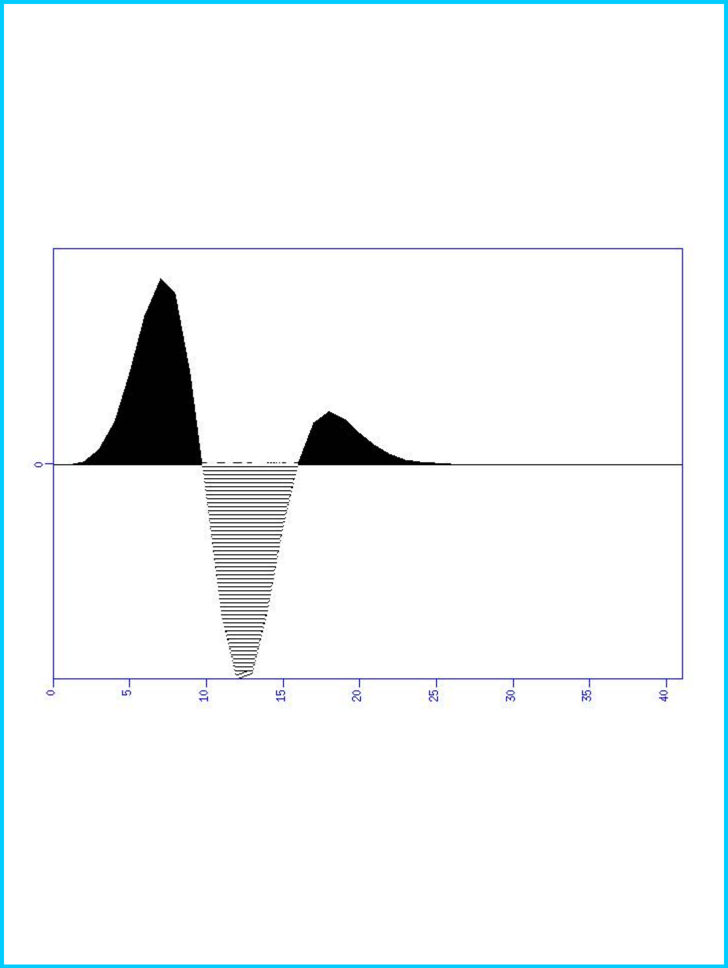


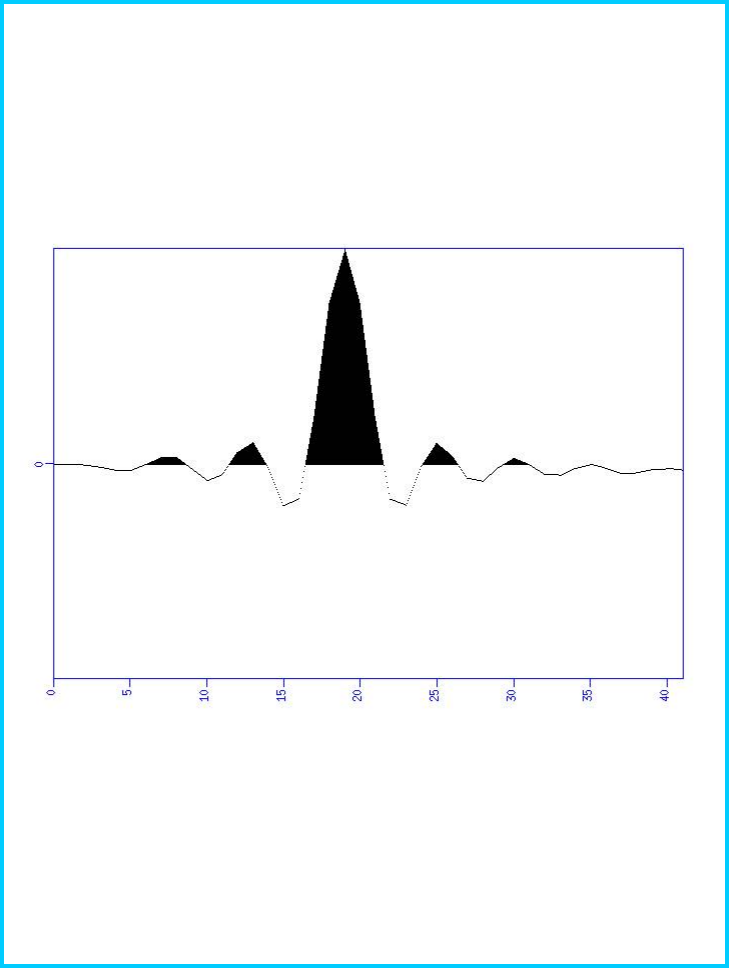
$\alpha = 100, \Delta t = 1ms, f_0 = 90Hz.$

Wiener Deconvolution Filters for Seismic Wavelets

The Wiener deconvolution filters as shown by Robinson (1967) are optimum in a least-squares sense and can be computed to have an optimum spiking position and these have been widely used throughout the industry. This is shown here for a wavelet from Dey (1999).

Deconvolution of a typical seismic wavelet.





Cascaded Deconvolution Filters for Seismic Wavelets

Apply a Wiener shaping filter or a frequency domain filter that will convert input wavelet, $W_1(\omega)$

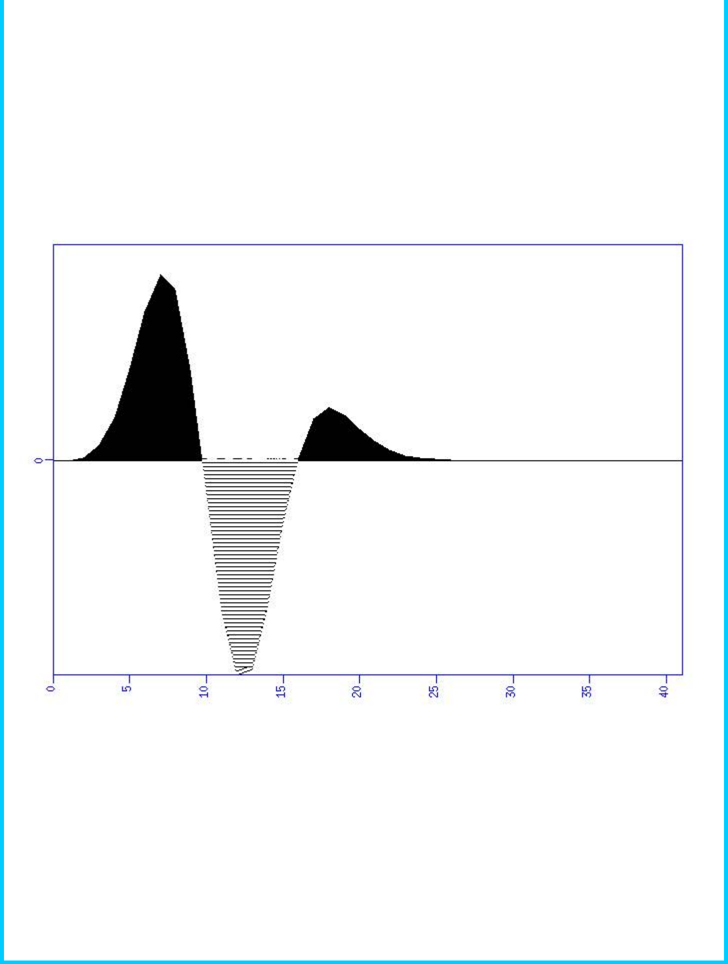
to an exponentially damped sinusoid, $W_2(\omega)$,

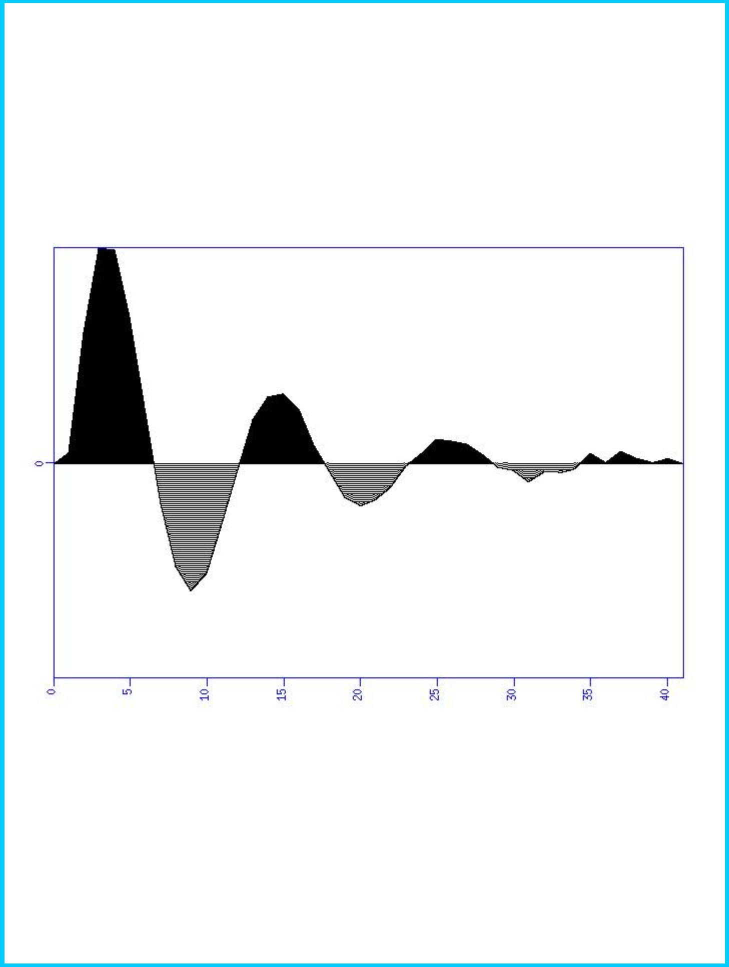
$$F(\omega_0) = \frac{W_2(\omega_0)}{W_1(\omega_0)},$$

and then apply an "exact deconvolution filter".

Note: There may be a need for a "stability factor" in the denominator of the above equation to avoid division by zero.

Result of shaping filter applied to original wavelet (left) to obtain approximation of damped sinusoid (right).

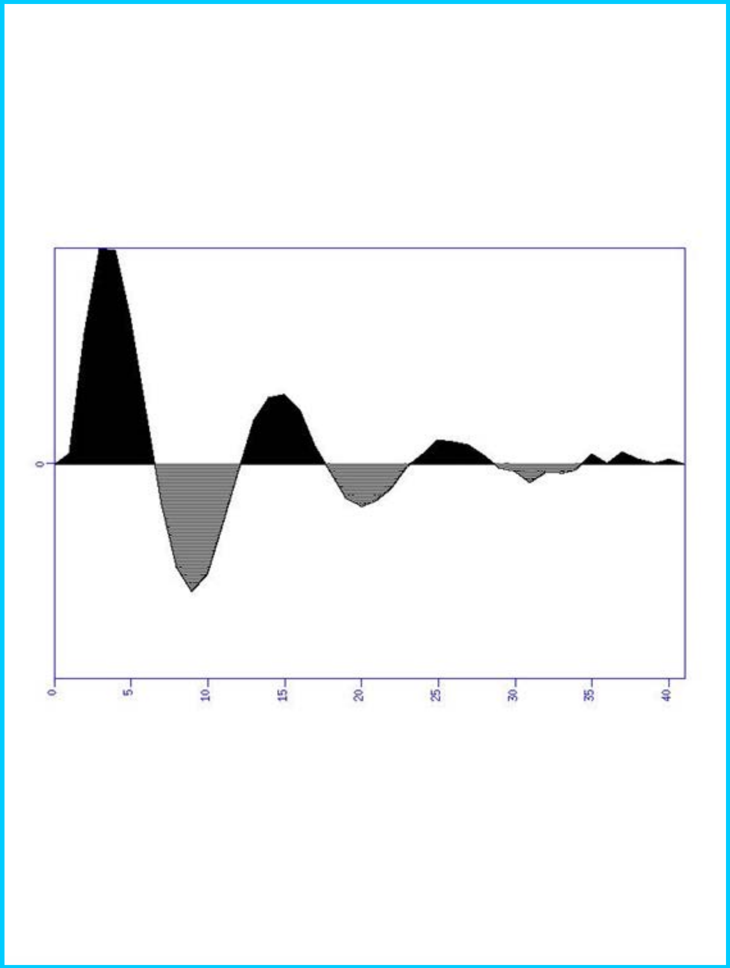


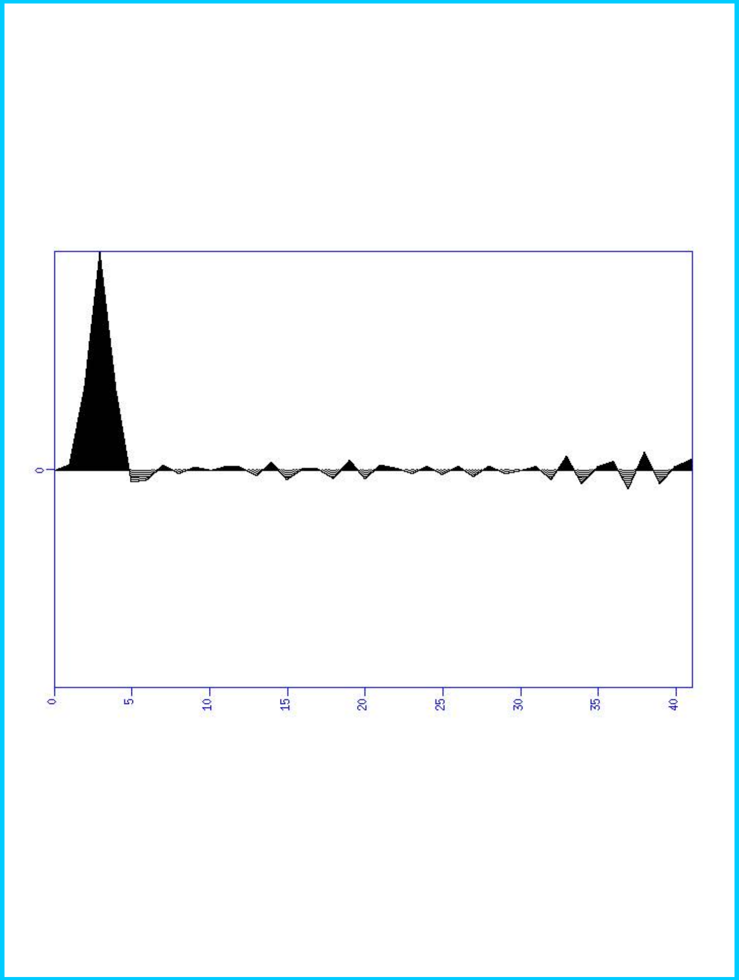


Cascaded Deconvolution

The cascaded deconvolution filter output or “resolving kernel” is not perfect but is an improvement over the traditional Wiener resolving kernel.

Shaped wavelet (left) and resolving kernel (right) resulting from the application of a deconvolution filter.

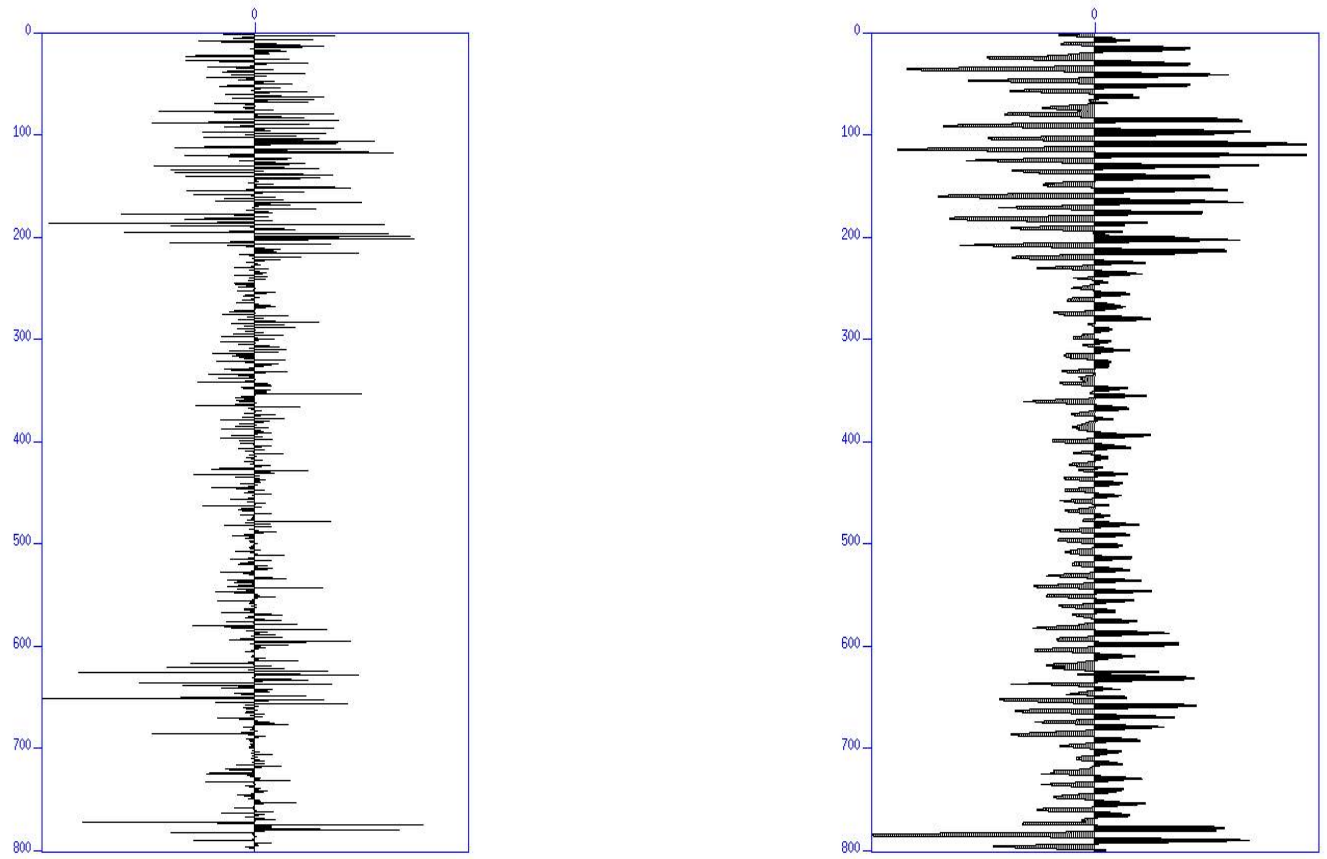




A test of cascaded deconvolution applied to synthetic seismograms

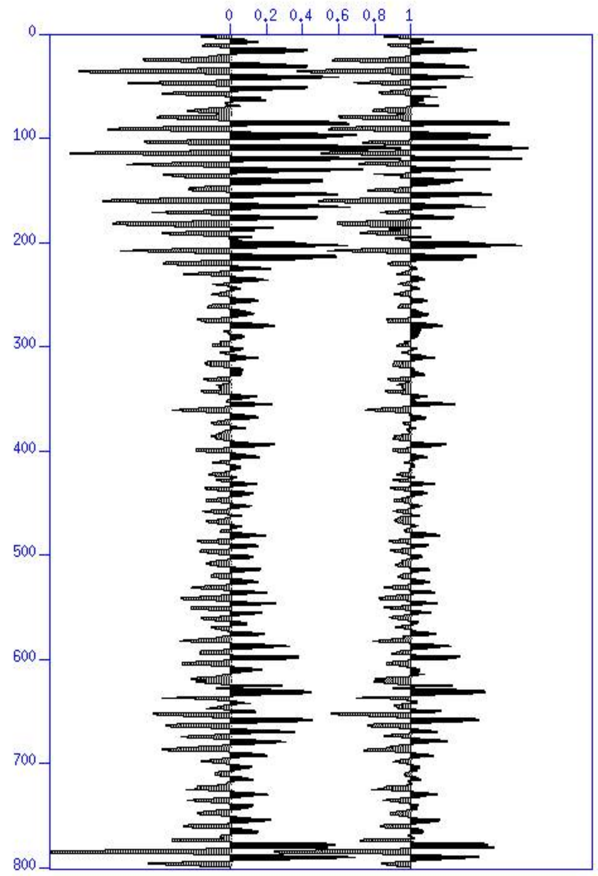
We now test the cascaded deconvolution on synthetic seismogram models.

Reflectivity derived from a Central Alberta well (left) and a synthetic seismogram (right) - resulting from the convolution of the reflectivity with the previous wavelet from Dey (1999).



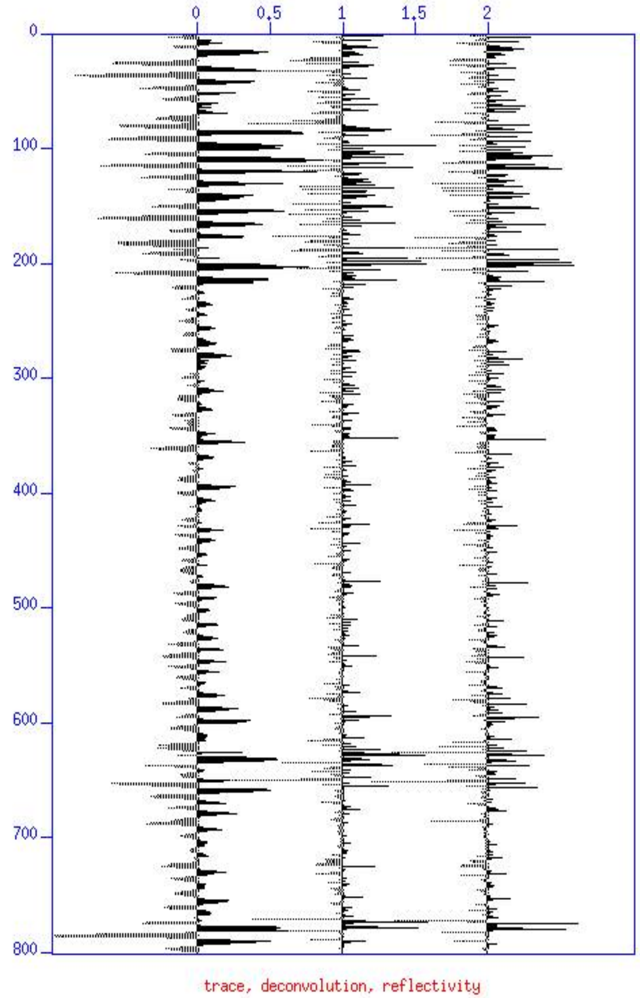
Application of the wave shaping filter

The application of the shaping filter to synthetic seismogram (left) produces a phase-shifted trace to be used in deconvolution (right).



Cascaded Deconvolution

A comparison of the input trace (left) with the cascaded deconvolution (middle trace) and the actual reflectivity (right trace). The deconvolution correlates very well with the desired reflectivity.



Conclusions and Recommendations for Future Research

1. An exponentially damped wavelet has an exact inverse (spiking) filter.

2. A shaping filter can be used to convert wavelets to a good approximation of an exponentially damped wavelet.

3.Cascaded deconvolution using a shaping filter and a deconvolution spiking filter appears to be a good alternative to conventional wavelet deconvolution.

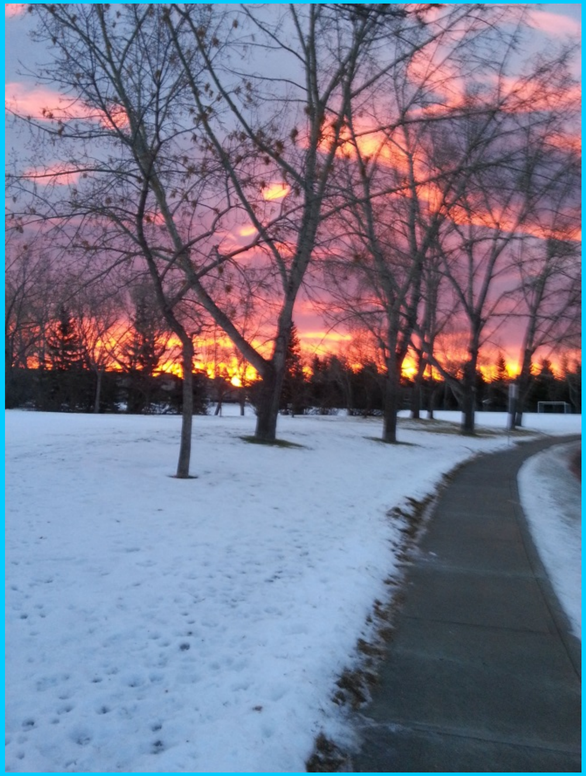
4. Cascaded deconvolution on synthetic seismograms may improve interpretation of models. (To be tested.)

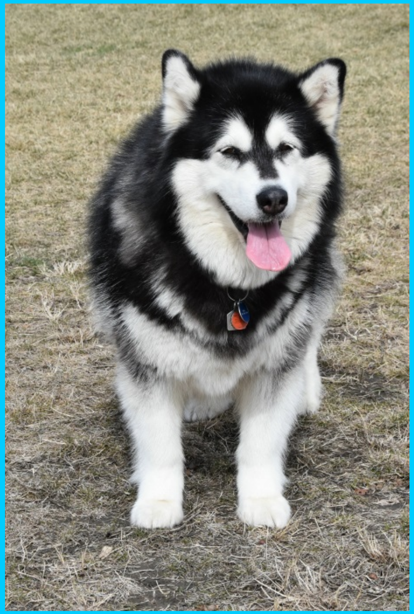
Acknowledgements

- Thanks to CREWES and NSERC for financial support.

Beauty

- There is beauty in the world. We just need to be aware of it.





$$f(t) = (f_0, f_1, f_2) = \frac{e^{\alpha}}{\sin \omega_0}\left[1,\ -2e^{-\alpha}\cos\omega_0,\ e^{-2\alpha}\right]$$

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