

Squeezing More Information out of 3D Seismic Data with a Match Filter and Possibly Squeezing More Oil Out of Oil Pools

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Introduction

3D seismic surveys and earlier 3D surveys in particular often contain information that is beyond visual resolution and therefore hidden from the interpreter. Signal processing on the workstation using what might be termed “geological based seismic deconvolution” has the potential to enhance the resolution to the point that this hidden information can be made visible and incorporated into the interpretation.

A 1989 3D dataset over a portion of the Sturgeon Lake field is match filtered to a single well to improve the resolution and the subsequent interpretation shows the main reef has “back stepped” from the lower D3 and that this lower stage is in an up dip position that has not been drilled.

The Match Filter Process

Our objective in recording and processing seismic data is to obtain as broad a frequency spectrum as possible with all frequencies at “zero phase”. We have made great strides in achieving this but various forms of noise and other artifacts sometimes do not allow us to fully meet our objectives.

A synthetic seismogram can be made noise free and with a broad enough “zero phase” spectrum to represent what we would like our data to be. Within the limitations of our actual seismic data we can use this synthetic data to optimize our 3D data set by a process called a match filter.

A match filter is a simple convolution filter that is designed on the amplitude spectra and the phase spectra differences between two traces. The operator when applied will make the target trace “match” the reference trace. In this case the reference is the well synthetic and the target is the corresponding trace in the 3D survey.

Of course nothing in geophysics is quite so simple and this is no exception. First of all the well has to be “stretched and squeezed” to fit the seismic trace. Then the parameters have to be adjusted in a trial and error basis to get the maximum resolution but still be at an acceptable noise level.

For the stretch and squeeze function it is best to use a wavelet in the synthetic that closely matches the seismic data in order to line up events as well as possible.

After the well synthetic matches the seismic events, the match filter parameters are determined.

To start, the synthetic wavelet is changed to the broadest possible wavelet that the seismic data might support and the data is filtered to that exact frequency band.

The next step is to determine the window for the match filter correlation. When making a well tie it is best to use a window that excludes as much noise as possible while including the maximum amount of consistent reflection data.

A first pass at the match filter will show the diagnostic of the phase spectra differences. The point at which the phase becomes erratic represents the useable frequency limit of the data.

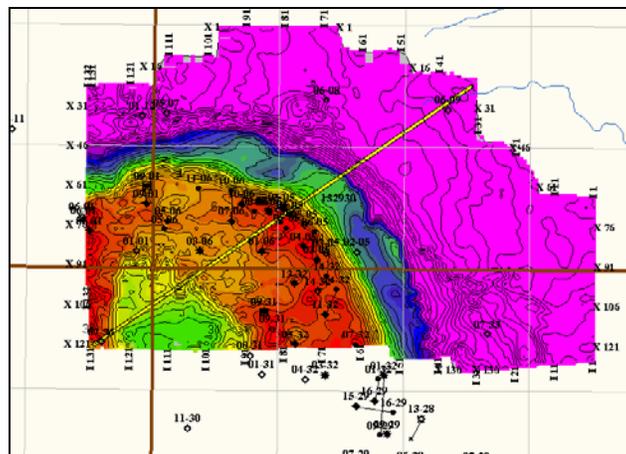
The match filter is then applied using these frequency limits as a starting point.

In this case, some of the useable frequency is so low in amplitude that the match filter ends up boosting these frequencies excessively. To compensate for this there is a maximum boost parameter that has a default of 40db. For this project it was reduced to 24db to prevent overdriving of the high frequencies.

Once an acceptable match was achieved, the operator was applied to the entire 3D survey. This operation takes a lot longer to explain than to do. In this case everything was done in less than five minutes and that included both the stretching and squeezing operation as well as several iterations of the match filter to optimize the frequency content.

Interpretation

Before doing the interpretation the data was rotated by -90 degrees to allow picking on the “zero crossing” instead of the peak. Since the well tie with a match filter gives reasonable confidence of flat “zero phase” data, the -90 degree rotation results in a “pseudo inversion” that often allows improved discrimination of stratigraphy.



Upper Leduc has back stepped from the Lower Leduc leaving an untested Lower Leduc in an up dip position.

Figure 1 is Leduc Structure as mapped on the match filtered data.

Interestingly the purpose of this exercise was to see if an improved interpretation of the data could be made particularly in the very noisy northeast portion of the 3D data set. The match filter and phase rotation not only improved the interpretation in the area of the noise problems, it also resulted in an unexpected redefinition of the reef slope and a possible prospect.

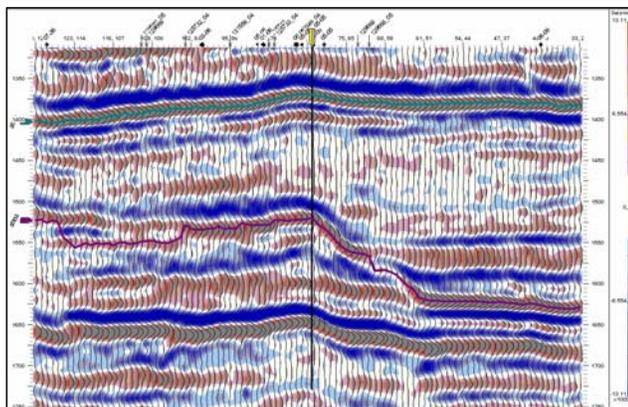


Figure 2. Reef line before applying the Match Filter

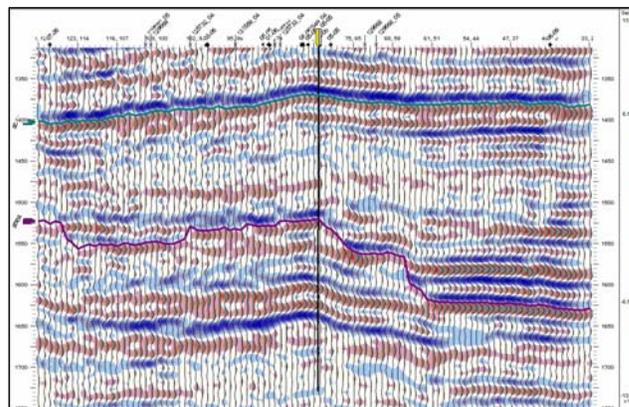


Figure 3. Reef line after applying the Match Filter

Figure 2 is the diagonal line depicted on the Leduc Structure Map before the match filter with the original interpretation. Figure 3 is the same line with the match filter and the phase rotation showing the northeast extension of the Lower Leduc as interpreted on the revised data.

Conclusion

The inclusion of interactive wavelet processing and match filtering in particular on a seismic workstation can provide opportunities to enhance interpretation by extracting more information from the data than would otherwise be possible. The process must be simple to use and take only a small amount of time to execute if it is to be useful to interpreters. When this process is done by the interpreter and not by the processor the direct link to the geological interpretation may lead to previously unidentified prospects.

References

- Kalmanovitch, N. , Townsley, J., 2006, Using an interactive match filter to advance interpretation, 76th Annual International Mtg. Society Exploration Geophysicists, Expanded Technical Abstracts.
- Dennis, L.P., Meisinger, D., Li, Y., Cline, R., Dennis, M., Kalmanovitch, N., 2000, Interactive line-tie, wavelet matching and geological based deconvolution GeoCanada 2000 Expanded Abstracts.
- Dennis, L.P., Peterson, F., Trickett, S.R., Link, B., 1999, Geological based seismic deconvolution, 69th Annual International Mtg. Society Exploration Geophysicists, Expanded Technical Abstracts.