Exploring below Seismic Resolution – Breaking the Bandwidth Limits

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Introduction

In the world of seismic stratigraphic interpretation and decision making to drill the prospects which are below the seismic resolution, every geophysicist have struggled to get a small boost in the clarity of seismic data. The seismic bandwidth is limited by various factors such as sweep frequency, geophone capability, absorption etc. For many decades it is shown by experiments that in the absence of noise the frequency of a signal can be increased substantially. Most recently, many of the trace shape analysis software show that there is more information in the seismic data than the temporal or ultimate resolution could define. Due to a marked increase in computer power, more ideas could be tested in small amount of time.

Method

Colton and Nautiyal, 1996 described the effects of cascading dipole filters in enhancing the resolution. Using this idea as a starting point we have developed a new tool to increase the resolution of surface seismic data without any external input (synthetics, VSP etc.). Astonishing improvements in resolution are seen in synthetic as well as in real seismic data.

Examples

We applied the method to many examples from varied sources including dynamite, vibroseis, and marine. Except few exceptions of pre-filtered and whitened data, the process works very well on nearly all type of stacks including offset, reflectivity, gradient and AVO attribute stacks. Below we are demonstrating one example from Canada (Vibroseis data)

The following example is from NW Alberta. Alberta basin is world known for its stratigraphic complexity and higher hydrocarbon potential. Figure 1a shows a portion of 2D seismic line (The whole line could not be displayed for confidentiality reasons). Blue are the peaks and the reds are the troughs. The frequency spectrum for the window is shown in Figure 2a. An oil producing well from the Cardium sandstone (Cretaceous Smoky Group) is overlain which have 10 meter thick sandstone unit just above TD (total depth) marked as a peak (blue) at 1280 ms. Although the original data was processed with a frequency enhancing workflow, it is hard to see lateral variations within the Cardium sand. The geology above Cardium is sand and shale sequence deposited in shallow marine environment before a major regressive phase near the top of the line The complex stratigraphic framework is completely obscured in the section 1a.

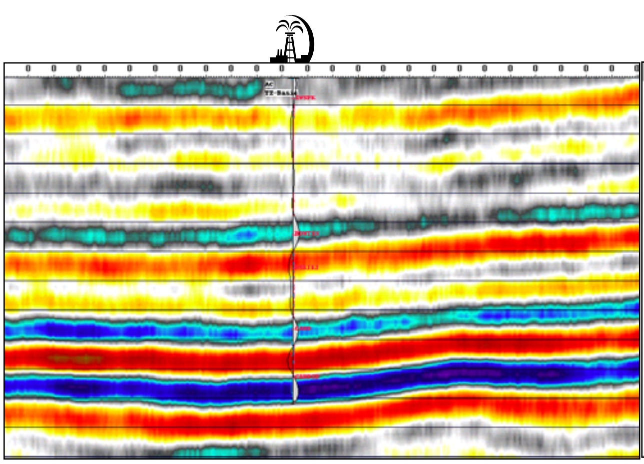

Figure 1a: 2D seimic line with a dominant frequency of 45-50 Hz.

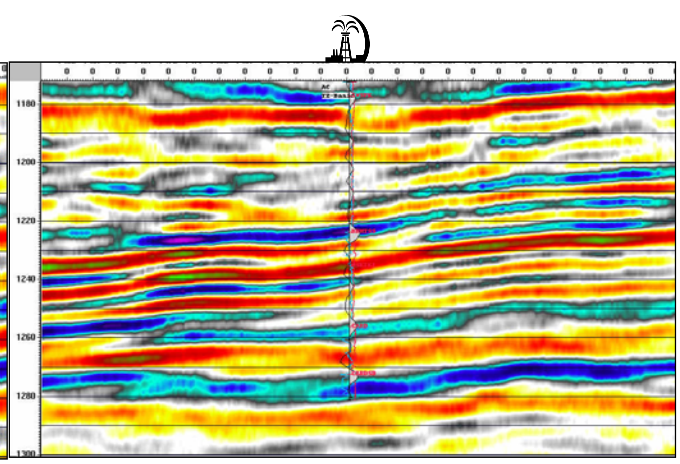

Figure 1b: The same line as in Figure 1a with resolution enhancement applied to it. Please note the depositional dip and stratigraphic clarity

Figure 1b is an enhanced migrated stack, the result of the use of advanced methodology. The frequency spectrum for the window is shown in Figure 2b. The increase in the temporal resolution is markedly visible in Figure 1b. The depositional dip and sequence stratigraphic structure of the interval which could only be inferred on low resolution line by advanced amplitude analysis is readily interpretable.

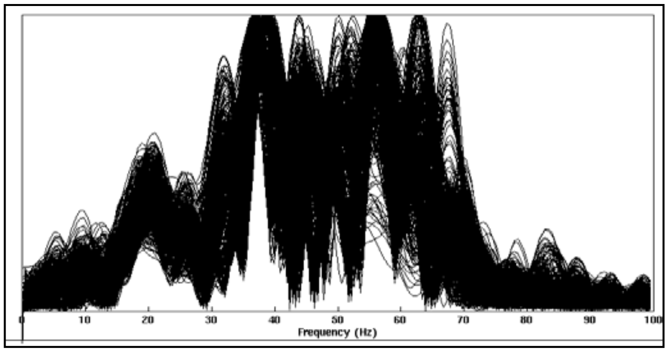

Figure 2a: The original frequency spectrum of th original migrated seismic line.

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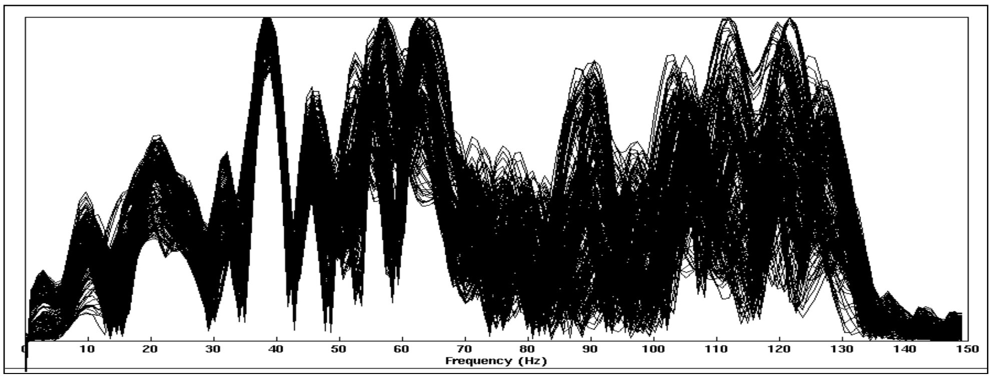

Figure 1b: The new frequency spectrum attained after frequency enhancement.

The seismic to well tie for the original and enhanced data is shown in Figures 3. The correlation validates the applicability of the frequency enhancement.

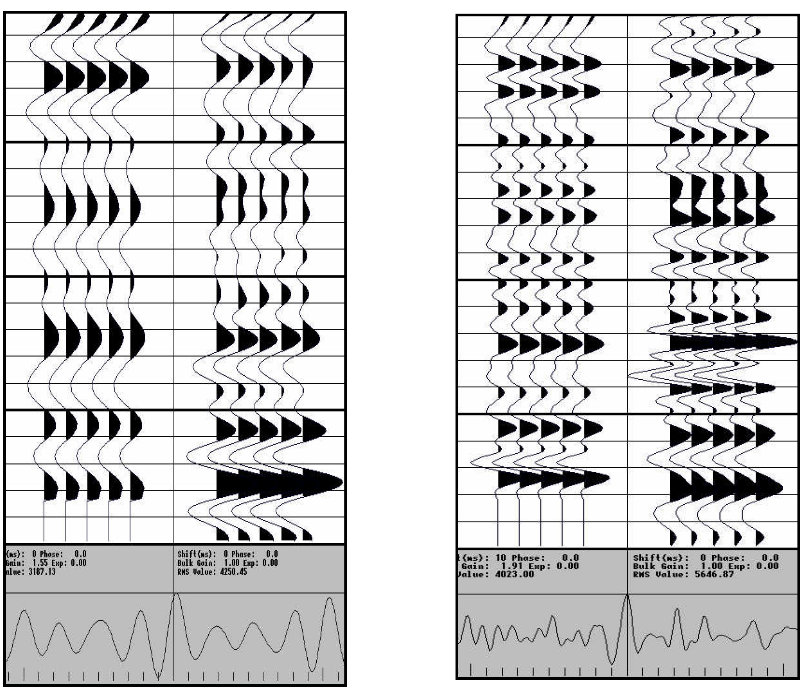

Figure 3: Seismic to well tie before and after data enhancement. Raw sonic log is used with no stretch or squeeze. No density log was available for this well. Lower frequency bandpass is 5-10-55-70 Hz and higher frequency bandpass filter is 5-10-110-140 Hz.

Conclusions and Future work

With many synthetic tests and real 2D and 3D examples we are able to show the validity of the process and its interpretability. In future our focus will be on enhanced AVO reflectivity stacks which might help in better reservoir characterization of thin sands, complex reservoirs and their elastic rock properties.

References

Colton, Penny B. and Nautiyal, Atul, 1996. Cascaded Dipole Filters: Extending the Limits of Seismic Resolution, CSEG Recorder, October 1996, 8-19.