Importance of Wavelet Phase for Inversion

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Summary

Simultaneous inversion of pre-stack P-wave seismic data yields rock property estimate volumes that can be very informative in the exploration for, and development of, hydrocarbons. The estimates are significantly improved if the seismic wavelet is either well known in both amplitude and phase across the full seismic bandwidth or preferably corrected to a zero phase wavelet prior to the inversion. In this talk, we present a comparison of inversion results from a central Alberta 3D survey for both a near zero phase corrected wavelet and a constant phase rotated wavelet. Our results will show the advantage of use the full phase correction.

Introduction

Land seismic data deconvolved using a minimum-phase based surface consistent deconvolution approach rarely results in a true zero phase dataset. Deviation from a zero phase result with the use of a minimum-phase assumption can result from an inability to accurately estimate a wavelet spectral shape that is fully isolated from the spectrum of the geology, noise, multiples, etc.(Henry, 1997). It has been a common practice among interpreters to simply apply a constant phase rotation to the seismic reflectivity data and then interpret or further process the results. Seismic Inversion endeavours to convert the reflectivity information back to the log or rock property domain and therefore enhance the lower frequency parts of the spectrum. Phase inconsistencies in the wavelet at the various frequency components causes increased noise and error in the inversion estimates.

Theory

Careful ties between the well logs and seismic can lead to a phase correction that produces a near zero-phase wavelet, which will in turn yield markedly improved inversion results. Logs are also prone to errors and differences within the seismic bandwidth, so accurate stretching between the well and seismic reflectivity is often important. The recognition of stable sequences in the geological section is a technique that can also be used to improve the wavelet phase estimate and correction. Time or frequency domain techniques can then be used to phase correct the seismic data to the desired near zero phase wavelet. Estimated impedance, density and Vp/Vs ratio from the pre-stack elastic inversion are much improved with the zero phase correction prior to inversion.

Examples

Figure 1 shows a typical central Alberta log suite for a well with a shear wave log. Note that the Vp/Vs ratio can be used to assist in distinguishing between sands and shales, with the Joli Fou shale being a distinctive high Vp/Vs ratio shale that can be mapped across large areas of Western Canada.
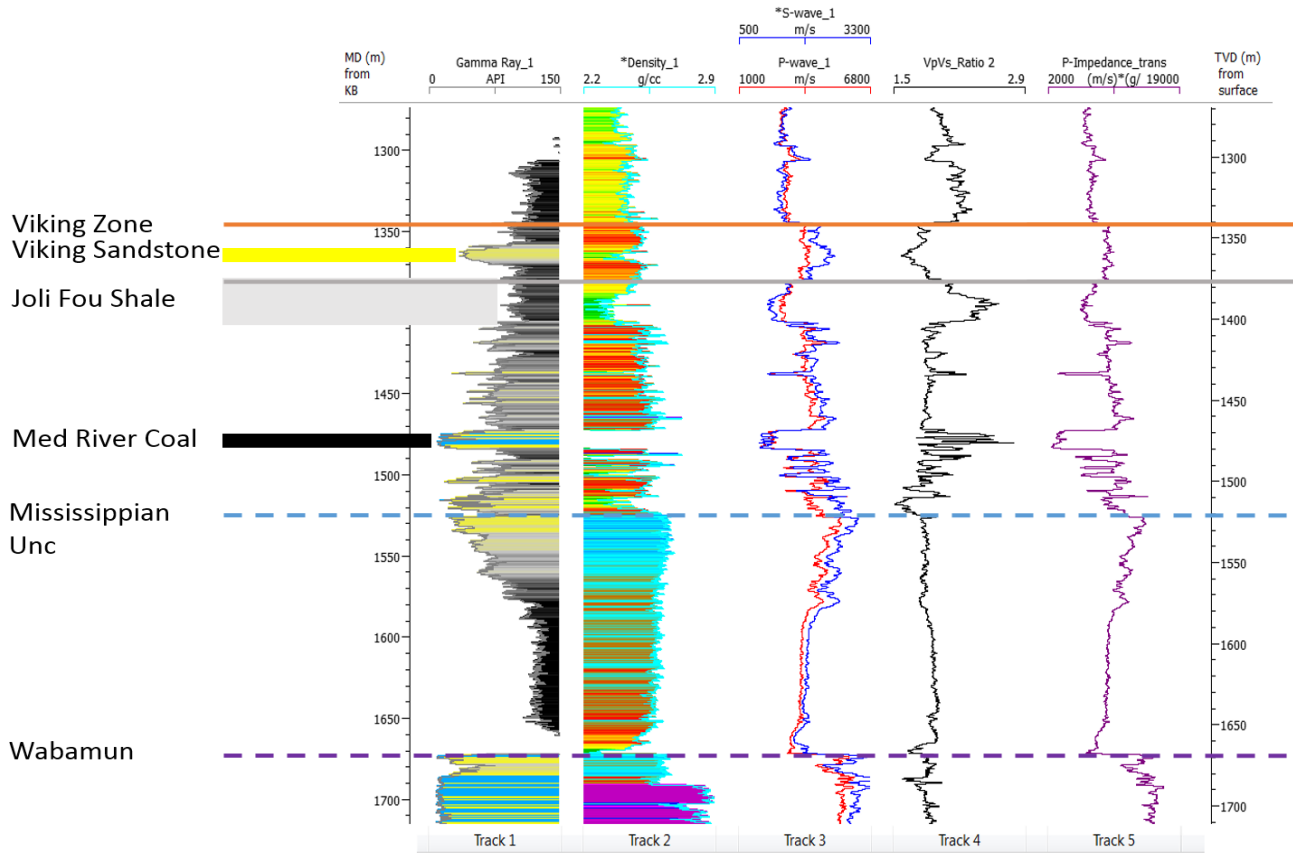
Figure 1. A typical Alberta well log suite.

The Vp/Vs ratios resulting from the inversion process for two wavelets are shown in Figure 2 below, the near zero phase wavelet result is on the left while the rotated phase result is on the right. Note the clear definition of the Joli Fou shale and the definition of the top of the Ireton shale interval, both demarked by high Vp/Vs ratios.
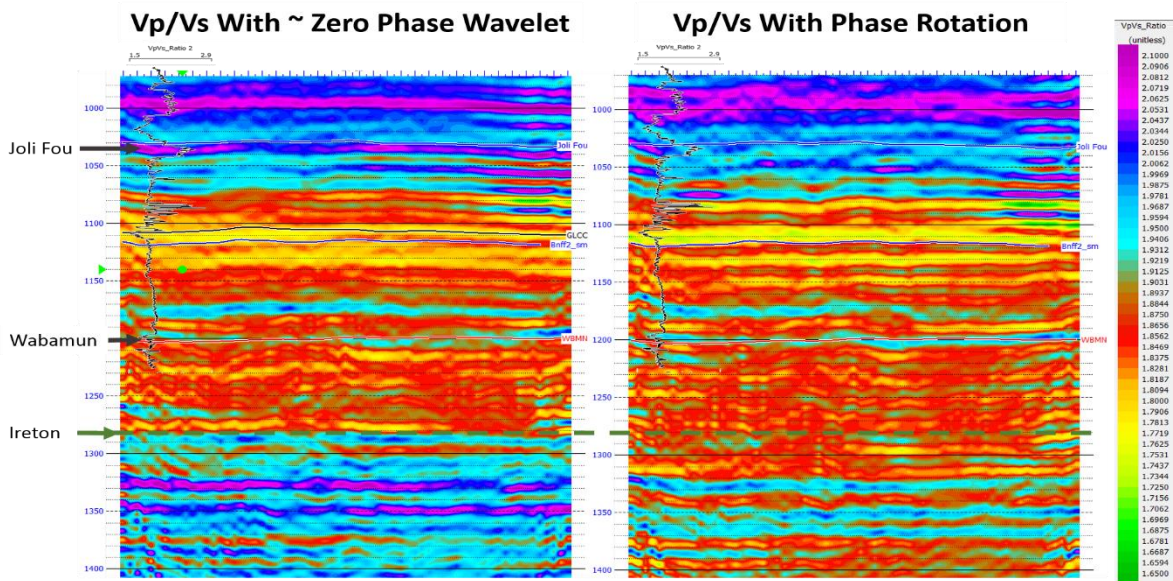

Figure 2. Inversion for Vp/Vs ratio using a true zero-phase wavelet is shown on the left, and with a constant phase rotation on the right.

Conclusions

Efforts to correct the seismic wavelet to near zero-phase produce markedly improved estimates of rock properties via pre-stack elastic simultaneous inversion. Enhanced descrimination of reservoirs, fluids and rock types can result from these improved elastic inversion results.

References

Henry, S. G. Catch the (Seismic) Wavelet, AAPG Geophysical Corner, March 1997