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Influences of Variation in Phase of Input Wavelet with Respect to Actual in Data on Seismic Inversion and Geological Interpretation

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Summary

Seismic Impedance Inversion is generally considered a direct geological interpretation approach. Through seismic modeling it has been shown that the phase of the input wavelet used for seismic inversion is an important parameters for precise geological interpretation. Inaccurate determination of phase results in erroneous results. Geology described by three layered model of low impedance thick layer sandwiched between two half space relatively high impedance layers has been considered for the study. A synthetic seismic response has been generated by convolving the model with known phase and frequency Ricker wavelet. The Response is from known model and known wavelet. The response has been inverted by same frequency, different phase Ricker wavelet as input wavelet to see whether the known model can be achieved. Study shows the accurate estimation of phase in the data is necessary for carrying out seismic inversion to bring out the Geology in terms of impedance. The wavelet with different phase as input for the inversion results into geology far off from the actual.

Keywords*: Seismic Inversion, Seismic forward and inverse modeling, wavelet, frequency, phase.*

Introduction

We, at our work center, routinely carry out model based seismic inversion for hydrocarbon and other subsurface related applications for predicting the properties beyond the drilled well location. The results from the subsequent drilled wells often do not match with the predictions made.

A project therefore has been undertaken to understand the dependence of seismic inversion results on various input parameters through modeling studies so that by selection of correct parameters better inversion can be carried for more accurate predictions. To begin with, the effect of variation of phase parameter of the input wavelet on inversion is considered for the study keeping other parameters (namely frequency of the wavelet, thickness, initial model etc.) affecting the inversion results same.

Synthetic seismic trace is generated by convolving reflectivity derived from a known geology described through three layered impedance model with wavelet defined by known frequency and phase. In seismic inversion, the geology in terms of impedance layers (no. of layers, thickness and impedance values) is estimated from the given trace and the extracted wavelet. Study is about how far from the generated synthetic trace and known wavelet, are we able to get back to the geology (which is known in this case) through model based seismic inversion, and the influences of variation of phase of input wavelet on inversion results (geology described in terms of impedance) with respect to the one used for generating the synthetic trace. To understand this, synthetic trace is inverted by changing the phase of the wavelet used for generating it. The outcome of the study is discussed through this paper.

Theory and Method

A three layered model having a low impedance thick layer of 40m (transit time150 µ s/ft and density 1.1 g/cc) sandwiched between two half space relatively high impedance layers (transit time135 µ s/ft and density 2.35 g/cc) has been constructed (Fig. 1). A synthetic seismic response from the model has been generated by convolving the reflectivity with 0 phase 35 Hz Ricker wavelet (Fig. 2). This amounts to knowing what geology in terms of impedance and thickness values of the layers with what known wavelet (frequency and phase) has given the synthetic response.

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The above synthetic response generated has been inverted with Ricker wavelet of same frequency and phase 0 º, 30º, 45º, 60º, 90º and 180º (Fig. 3 from (a) to (f) respectively) taking the above model as initial input model

The results of the inversion with various phases as input are shown in figures 4 to 9.

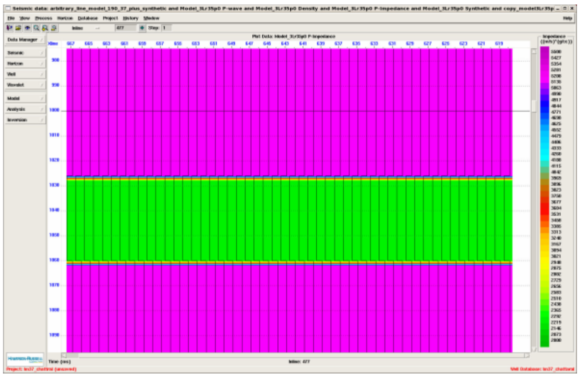


Fig. 1 Three layered initial model

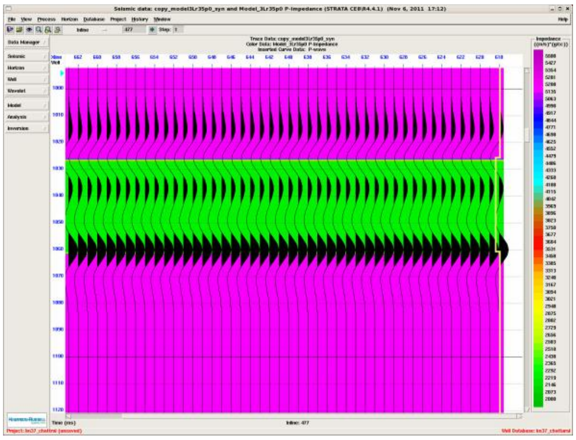
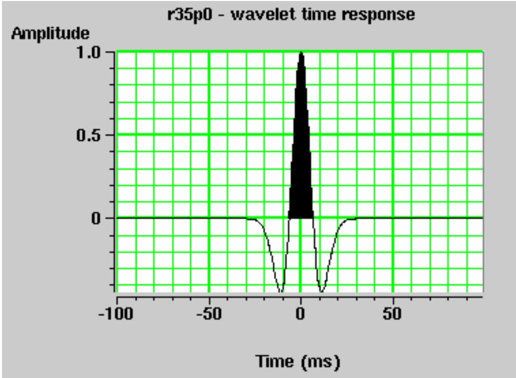
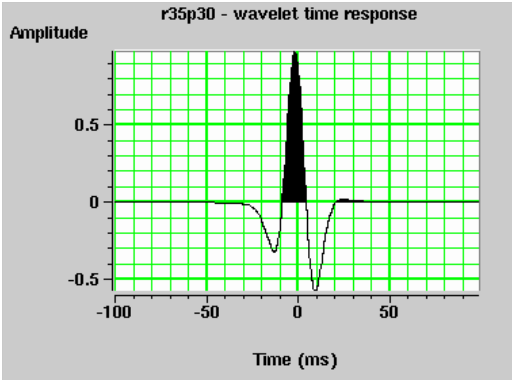


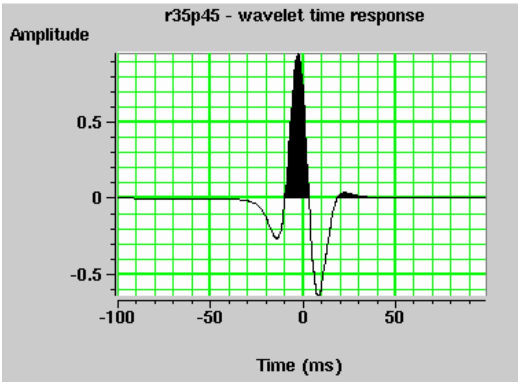
Fig. 2 Three layered initial model with ricker wavelet (after Anstey N. A., 1978)



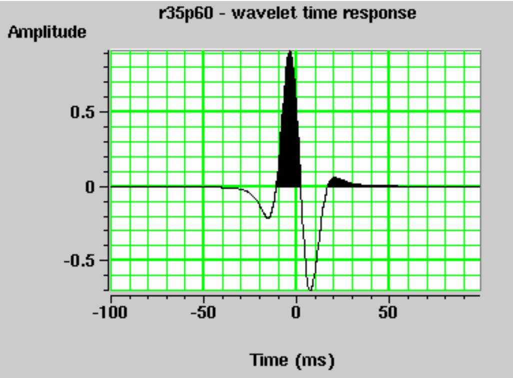
(a)



(b)



(c)



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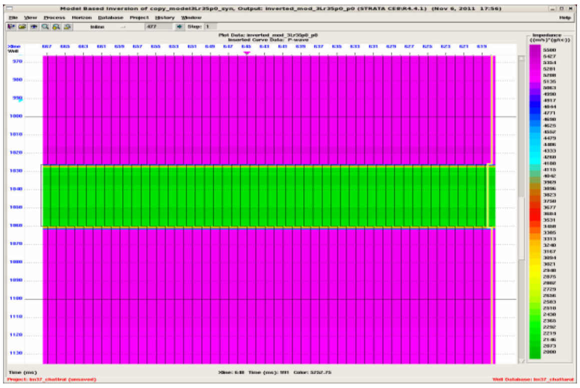
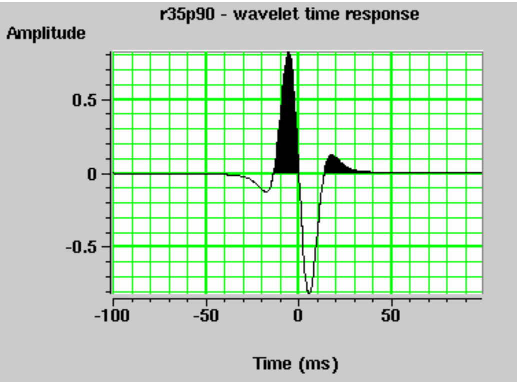
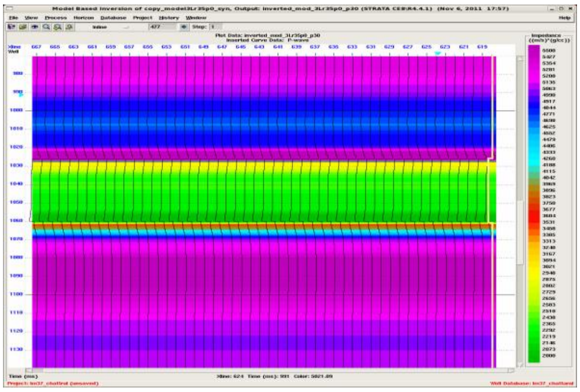


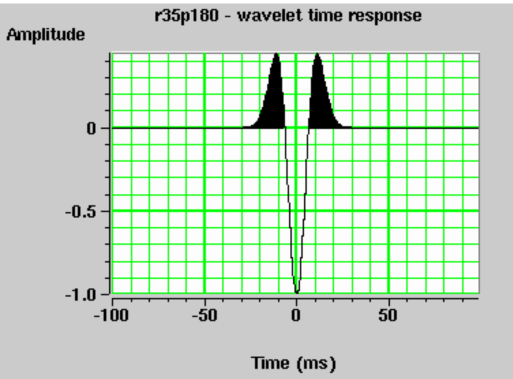
(4)



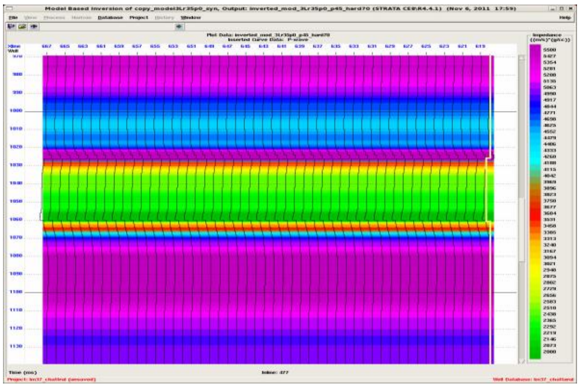
(e)



(5)

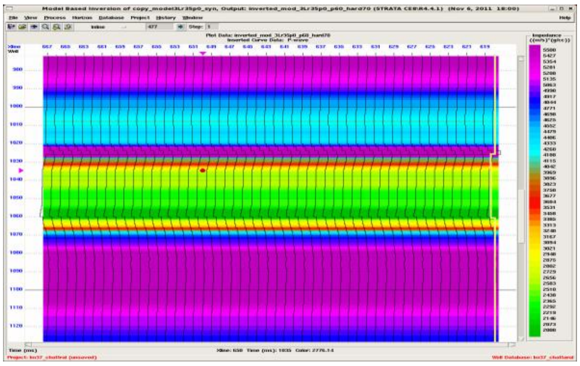


(f)

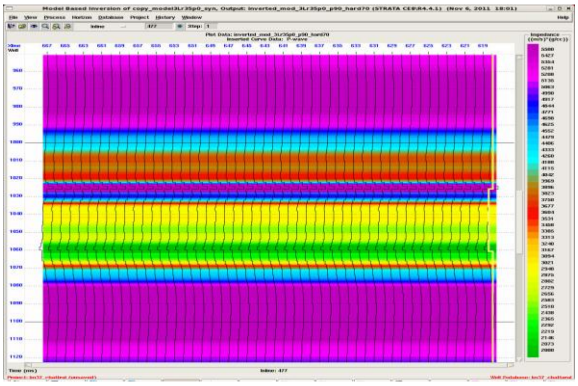


(6)

Fig. 3 Ricker wavelet with 35 Hz frequency and Phase values of 0, 30, 45, 60, 90 and 180 degrees from (a) to (f) respectively



(7)



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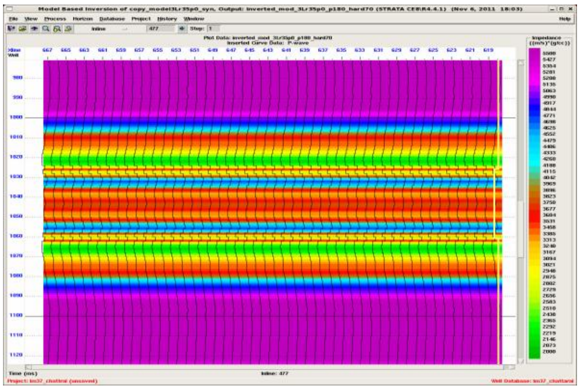

(9)

Fig. 4 to 9 illustrated inversion models with wavelets of phase values of 0, 30, 45, 60, 90 and 180 degree respectively.

Observations

In model based inversion, comparison of response generated by convolving the reflectivity derived from some initial impedance with the input wavelet is done with the known seismic trace to be inverted. Input model is modified in terms of no. of layers, thickness and impedance values to minimize the mismatch between the two.

Following are the case by case results:

In case of 0º phase of input wavelet i.e., matching with the phase of the actual wavelet used for generating the response, the inversion results into the desired geology described by the impedance. (Fig.4).

In case of phase off by 30º with respect to the phase of the actual wavelet, the inversion does not result into the desired model. Though the low impedance layer in the model is brought out, a considerable variation in result is observed An additional layer of significant thickness of marginally lower impedance, above the interface of high to low impedance is observed. There is a gradual transition from low to high impedance interface, contrary to sharp contrast as in the initial model (Fig.5).

With the increase of phase off by 45, 60 and 90, the results of inversion remains similar to that of 30 but the impedance of the additional layer above the high to low impedance boundary keeps decreasing and the transition interval at and below the low to high boundary also keeps increasing. (Fig.6, 7 and 8)

The thickness and values of impedance of the new layer is considerable to influence the prediction made out of these results. The higher the phase shift, the higher the error in impedance results.

The case of 180 degree phase difference, the inversion results show a relatively high impedance layer within the low impedance layer with respect to the desired result. Considerable symmetry about the low impedance layer, and a well spread transition of impedance value outside is also observed. (Fig.9).

Conclusions

- The wavelet as input having different phase with respect to actual data for the inversion results into geology far off from the actual.
- The inversion results will primarily be governed by the degree of variation in the phase of input wavelet.

- Study is carried out considering a simplistic three layered model for influence of phase on inversion results. In real case scenarios consisting of multiple layers, pinch outs, etc. inversion results will immensely be affected by variation in phase.

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