A "synthetically-guided" investigation of true amplitude processing

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Study Motivation

Today's explorationist commonly faces the difficult task of pursuing reservoir targets that are more and more challenging, and which in some cases approach the threshold of seismic resolution. Chasing subtle stratigraphic traps instead of big hydrocarbon accumulations is more the norm than the exception.

To better aid the exploration effort, the seismic industry has revived and improved older techniques, such as poststack acoustic impedance inversion, amplitude versus offset analysis, multi attribute analysis, and developed new ones such as the lambda-mu-rho technique. The aim of these improved approaches is to facilitate a better understanding of the reservoir setting and thus to improve drilling success.

One of the fundamental assumptions made by these integrated approaches to the exploration process is that the recorded seismic amplitudes, which embody information about the physical properties of the rocks (rigidity, incompressibility, etc.), are preserved throughout the many stages of processing which raw seismic data require in order to become an interpretable set of information. Understandably, a good deal of attention has been cast on the issue of improving the integrity of relative amplitude preservation in seismic processing (e.g. Ursin and Ekren, 1995; Downton, 1998). Still, much debate exists over the question of precisely what processing algorithms ought to be included in a production AVO "pre-processing" run stream. Controversial issues include the questions of whether or not to run Radon (Tau-p) multiple attenuation, multi-channel noise attenuation, and/or prestack migration on data prior to AVO analysis.

Other topics capable of fostering deep rooted and differing opinions are the questions of which surface consistent deconvolution components should be used in constructing the operators and what type of scaling should be applied to the data (e.g., deterministic vs. statistical, trace by trace vs. multi-channel).

In this study we attempt to gain insight into the answers to some of these questions by measuring the distortion introduced by certain common processing algorithms in a carefully controlled synthetic test environment.

Objective of the paper and tests performed

The objective of this paper is to investigate how well the seismic amplitudes are preserved throughout the typical "true amplitude" processing flow.

For the purpose of our testing we used a synthetic data set with a known AVO anomaly. We added various artifacts to the data set and applied typical amplitude preserving processing techniques designed to restore the data to their original, uncontaminated state. The ideal AVO anomaly was compared to its processed counterpart and the difference between the two was measured.

Some of the processing techniques examined in the study are:

- Surface consistent deconvolution
- Surface consistent scaling
- FX prestack noise attenuation
- Tau - p prestack noise attenuation
- Tau - p multiple attenuation: fast and slow multiple

A representative example of our findings for Tau-p multiple attenuation is shown in Fig. 1 and Fig. 2.

Conclusions

Based on our testing thus far we have concluded that by applying certain processing techniques in a careful manner, in a controlled synthetic test environment at least, it is possible to reasonably maintain the integrity of the seismic amplitude information, thus making viable the option of further application of various reservoir analysis techniques. However, our tests also showed that an acceptable distortion of the amplitudes is encountered when we apply any processing algorithm. This distortion might be acceptable bearing in mind the complexity and the nature of the artifacts, which have to be eliminated in the processing stage.

Our tests led us to the conclusion that Tau-p and FX pre stack noise attenuation algorithms, if applied carefully, are solid ways of enhancing the signal-to- oise ratio in the preparatory stage of an AVO analysis exercise.

Regarding surface consistent deconvolution, our results suggest that certain noisy data sets may benefit from including the offset component (zero-phase, over a limited frequency band) in the operator construction. This finding contravenes conventional "decon wisdom", which holds that the offset component ought never to be applied.

References

Downton, J., 1998, Getting the benefits of AVO inversion, GeoTriad 1998, Expanded Abstracts, 354-355

Ursin, B., and Ekren, B. O., Robust AVO analysis, 1995, Geophysics, 60, 317-326

List of Figures

Fig. 1:

Initial synthetic gather with an AVO event at 1300 ms (blue) contaminated by a multiple (orange).

Processed synthetic seismic gather with an AVO event at 1300 ms (red) with the multiple removed by a Tau-p algorithm.

Tau-p spectra (p traces) for the initial synthetic gather.

Tau-p spectra (p traces) for the processed synthetic gather with Tau-p reject filter superimposed (orange).

Fig. 2:

Initial synthetic gather with an AVO event at 1300 ms (blue) contaminated by a multiple (orange).

Processed synthetic seismic gather with an AVO event at 1300 ms with the multiple removed by a Tau-p algorithm (red).

Amplitude versus offset composite display of:

- The AVO event contaminated by a multiple (blue) and its regression line (light blue)
- The AVO event after Tau-p multiple attenuation (red) and its regression line (pink)
- The ideal AVO event (yellow) and its regression line (black)

Display of standard deviation, measured relative to ideal AVO reference for:

- The amplitudes of the AVO event contaminated by a multiple (blue)
- The amplitudes of the Tau-p processed AVO event (red)

Fig. 1

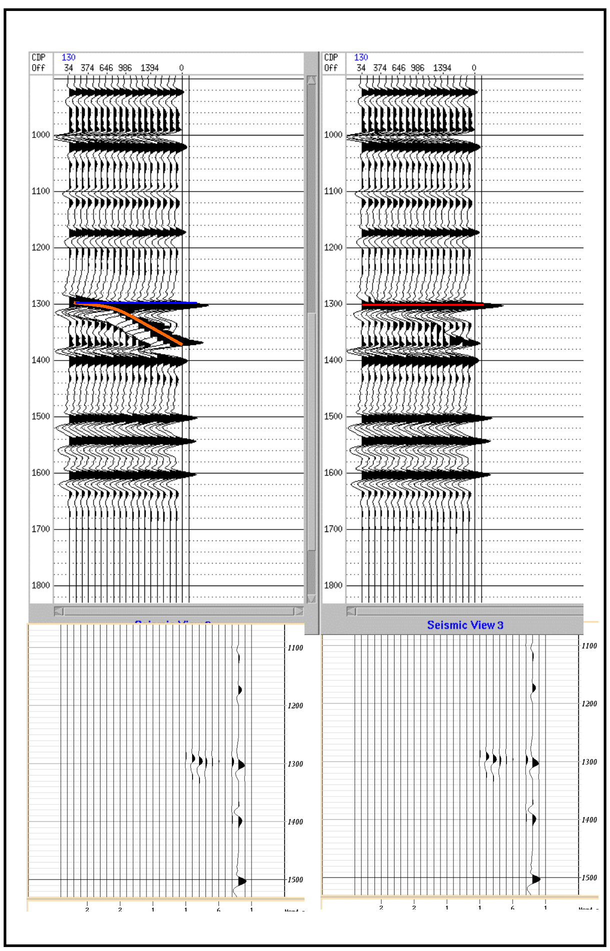
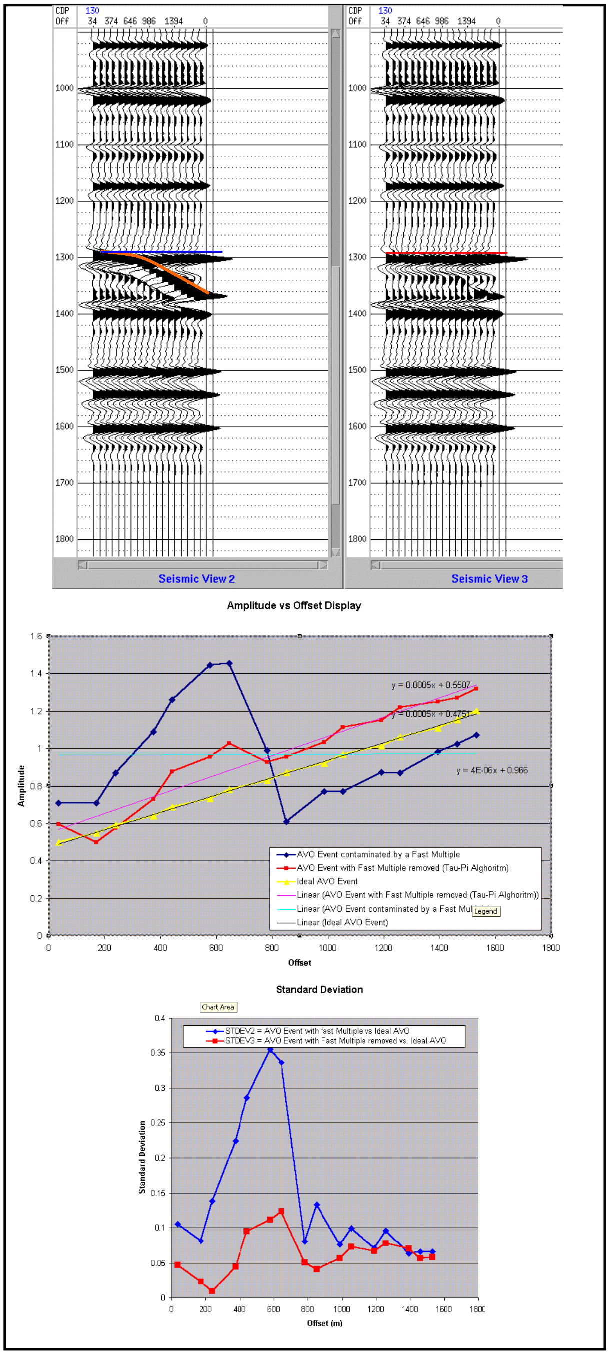


Fig. 2


Seismic View 2
Seismic View 3
Amplitude vs Offset Display
y = 0.0005x + 0.5507
y = 0.0005x + 0.4751
y = 4E-06x + 0.966
AVO Event contaminated by a Fast Multiple
AVO Event with Fast Multiple removed (Tau-Pi Alghoritm)
Ideal AVO Event
Linear (AVO Event with Fast Multiple removed (Tau-Pi Alghoritm))
Linear (Ideal AVO Event)
Amplitude
Offset
Standard Deviation
Offset (m)