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Multiple Attenuation with Deterministic Deconvolution using VSP Data (Case Study: South West of Iran)

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Abstract: Estimation of accurate deconvolution operator using VSP downgoing waves has been considered as an efficient method to suppress multiples. Practical experiments show that while using the VSP deconvolution operator, seismic source wavelet not be eliminated completely. The residual wavelet presented in seismic data makes some miss matching between VSP corridor stack and surface seismic. Contamination of seismic data with wavelet would be led to uncertainty in further study such as seismic inversion. This also makes the mistake through the interpretation of seismic events. In this approach, application of shaping deconvolution using upgoing waves on seismic data shows a good agreement between VSP and surface seismic data. The final results after this methodology had pleasant corresponding with synthetic seismogram generated by well logs and met the geological events logically.

Key words: Deconvolution, seismic inversion, VSP, data, stack

INTRODUCTION

Many well-known demultiple tools such as deconvolution (in time, frequency and slant stack domains), radon-transform demultiple, frequency-wave number (f-k) demultiple and various model-based approaches are used during seismic data processing, particularly for marine data, to eliminate the multiples caused the most serious problems through interpretation. Suppression of multiple is fundamentally difficult because multiples are not very separable from primaries by criteria such as periodicity, moveout velocity and spectrum. Some model-based demultiple techniques show encouraging results but require an accurate model (Wiggins, 1988; Berkhout and Verschuur, 1995). In the other words, it requires a precise reflectivity model containing the prior and proper model of multiples with both correct kinematics and exact amplitude.

However, a good model to image the primaries is a good model to image the multiples too. The VSP data generally shows the multiple models in the downgoing wavefield. The upgoing wavefield has also built-in multiple trains within it. Lee and Balch (1983), Hubbard (1979) and Ross and Shah (1987) used the downgoing wave from a single level to deconvolve all the VSP traces.

In this study, researchers used the downgoing filter operator to attenuate the multiples in the surface seismic data. The shaping deconvolution also was applied on surface seismic data using corridor VSP stack to remove the source wavelet effect.

DATA ACQUISITION

VSP surveying was run in an oil field in the South West of Iran. Researchers used the Schlumberger's four-level, three-component geophone tool that had 15 m spacing between receivers for VSP surveying. The recording was performed from 25-4235 m bellow the rotary table. Figure 1a shows the raw data recorded in VSP vertical component during surveying. The vibrator projected in 35 m far from the well as a source point swept the wave train with frequency range 8-80 Hz to the earth. The 2D seismic line crossed the well was collected in 480 channels per ensembles with 25 m station intervals to interpret and characterize the reservoir. Presence of inter-bed shales in the strata makes the strong local contrasts of acoustic impedance led to generate short period multiples. The small difference between velocities of primaries and multiples is an important factor caused to weak ability of conventional methods to eliminate the multiples during seismic processing. A semblance spectrum analysis in the corresponding CDP to the well shows this issue in Fig. 1b.

METHODOLOGY

Processing the VSP data was started by building the interval P-Wave Velocity Model using the first arrival times picked in vertical component. Then, true amplitudes were recovered for spherical divergence effect using the Constructed Velocity Model.

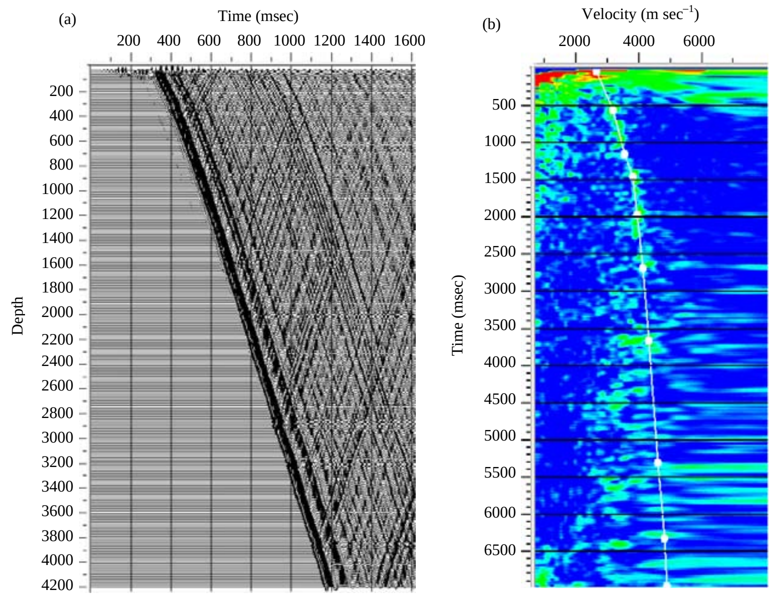

Fig. 1: a) VSP recorded data in vertical component and b) semblance spectrum for velocity analysis computed in corresponding CDP to the well position

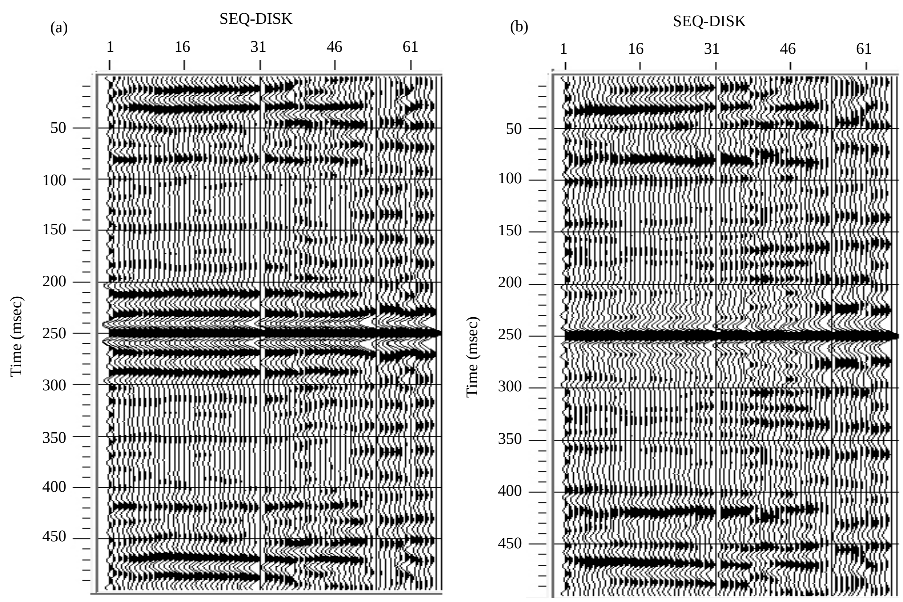

Fig. 2: Comparison of autocorrelation in VSP data a) before and b) and after applying deconvolution. Zero lag time is equal to 250 msec

One of the fundamental processing steps for vertical seismic profiling data is the wavefield separation. Practical experiment on data showed that the best separation of upgoing and downgoing waves would obtained in FK domain. Successful wavefield separation is important because the removal of undesired wave is a precondition for optimal imaging. However, some energy scattering may be occurred during filtering. The wavefield separation was followed by extracting the deconvolution operator in a window of 500 msec around the P-wave first arrivals. In Fig. 2, comparison of autocorrelation before and after applying deconvolution shows the good suppression of multiple amplitudes around the zero lag time equal to 250 msec. The corridor stack data were obtained by convolution of filter operator in upcoming waves and make the averaging through the specified polygon. The stacked data were then equalized, followed by a time-variant spectral whitening operation. F-X

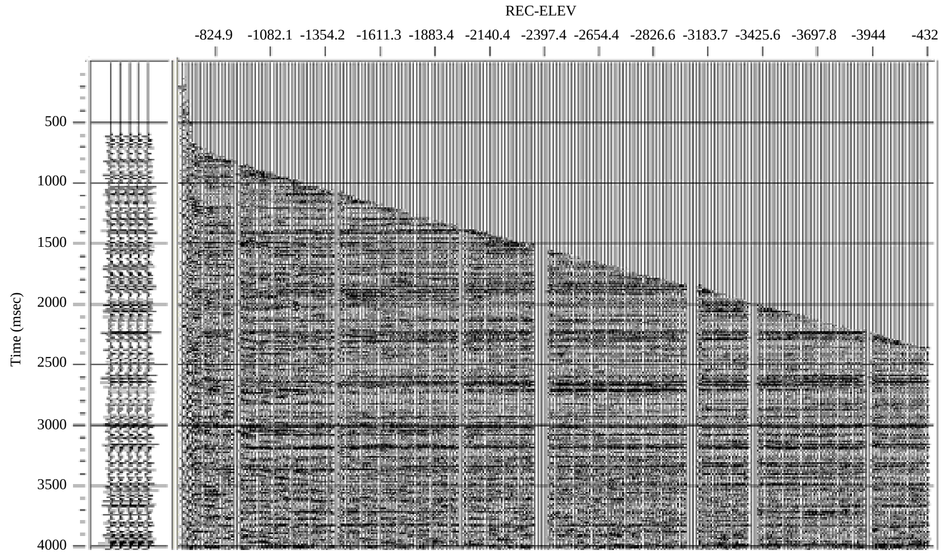

Fig. 3: The VSP corridor stack generated by stacking the flatten upgoing waves

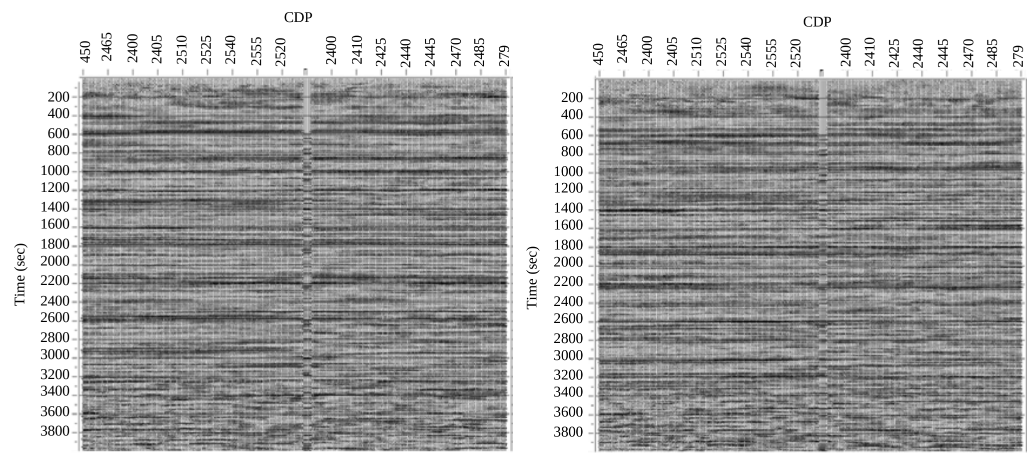

Fig. 4: Comparison of the 2D seismic stack with VSP corridor stack. a) stack section processed conventionally using statistical deconvolution; b) stack section after applying downgoing wave filter operator and shaping filter using VSP corridor stack

deconvolution was used to fill in empty intervals and removes the random noises. Figure 3 shows the corridor stack obtained from the VSP data. Simultaneously, the standard processing sequences were applied on the 2D surface seismic data using VSP results. The true seismic amplitudes were recovered using generated velocity model from the VSP in the well location. Since, the deconvolution operator extracted from VSP data was specified the multiple models in time domain, the surface seismic deconvolution was performed using downgoing wave operator. The final stack result improved some extent relevant to the conventional processing output.

In spite of satisfaction in processing but some miss-ties considered the surface seismic data with the VSP corridor stack. The effect of wavelet shape changing spatially through the seismic data might be the reason of this miss matching. Esmersoy (1990) and Labonte (1990) believe that using a model-type filers would be improved the results. The his approach enables us to overcome on this issue by applying the shaping deconvolution on seismic data to remove the wavelet effect. For this purpose, the time variant shaping filter was generated from the traces around the well using the VSP corridor stack data. Convolution of shaping operator removed the residual wavelet effect from the seismic data. Figure 4 shows the good correlation achieved between seismic and VSP corridor stack.

CONCLUSION

In this study, the deconvolution operator extracted from the VSP downgoing waves was used to attenuate the multiples. Comparison of corresponding CDPs in the stack section to VSP corridor stack at the well position showed the miss-matching between reflectors. In this case, researchers considered to the residual wavelet remained in the seismic data caused this effect. Application of the shaping deconvolution estimated from the VSP upgoing waves on the real data shows the good correlation between seismic and VSP corridor stack

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