AVO processing of walkaway VSP data at Ross Lake heavy oilfield, Saskatchewan

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ABSTRACT

The AVO processing and analysis of walkaway VSP data at Ross Lake heavy oilfield, Saskatchewan is described in this report. A walkaway VSP geometry has advantages for AVO analysis: True amplitude processing is feasible and undesired wave-propagation effects can be minimized. At the top and the base of the target channel sand, the synthetic seismogram and walkaway VSP processing results show a similar amplitude variation with offset for the reflections of both PP and PS waves. These results indicate the promise of rock properties inversion using AVO gather from walkaway VSP.

INTRODUCTION

The Ross Lake heavy oilfield (operated by Husky Energy Inc.) is located in southwestern Saskatchewan. The exploration target is the Cretaceous channel sand in the Cantuvar Formation of the Mannville Group. Considering the advantages (FIG. 1) of using walkaway VSP data for AVO analysis, the walkaway VSP and multi-offset VSP were processed at the reservoir interval at the Ross Lake, Saskatchewan.

CONCLUSION

A walkaway VSP geometry has advantages for AVO analysis. True amplitude recovery and wave propagation effects removal are feasible for walkaway VSP data. The use of corridor common-shot stack can improve the signal-to-noise ratio, and minimize undesired wave propagation effect at the same time. At the top and the base of the target channel sand, the synthetic seismogram and walkaway VSP processing results show comparable amplitude for both PP and PS waves. These results indicate the promise of rock properties inversion using AVO gather from walkaway VSP.

Estimating seismic attenuation (Qp & Qs) from rock properties

As one of the basic attributes of seismic waves propagating in the earth, attenuation (Q) has important values in the acquisition processing, and interpretation of seismic data. In this report, the relationship between seismic attenuation and rock properties is investigated using VSP data and well logs from the Ross Lake heavy oilfield, Saskatchewan.

INTRODUCTION

The results reveal that Q values of P- and S-waves relate more to P modulus, Vp/Vs, effective porosity, and shale volume in the study area. The equations for Q estimation using these four rock properties were then derived using multiple parameter least-square regression method. The results show multiple rock properties have better prediction quality than a single rock property.

FIG. 1. The influence of a single rock property value on prediction accuracy of Q value from rock properties. The prediction of Q value is from linear regression equation including all the 6 rock properties, except for the one noted right below the bar plot.

FIG. 2. Comparison between real and predicted Qp and Qs values using the equations above.

FIG. 3. Hmax (a, horizontal radial), Hmin (b, horizontal transverse) after a horizontal rotation of X and Y components, and 2 component data (c) of the offset 558 m shot (AGC applied, the green line indicates the first arrival pick).

FIG. 4. Downgoing P waves (a), downgoing BV waves (b), upgoing P waves (c), and upgoing BV waves (d) separated from Hmax and Z data of the offset 558 m shot (AGC applied, the green line indicates the first arrival pick).

FIG. 5. Downgoing P waves before (top left) and after (top right) deterministic deconvolution, as well as the corresponding amplitude spectra (the average spectrum is in blue) and average phase spectra (shot offset 558 m).

FIG. 6. Upgoing P and BV waves after a deterministic deconvolution with operator derived from downgoing P waves (shot offset 558 m, the green line indicates first arrival pick).

FIG. 7. Downgoing P waves before and after mean scaling (multiplied to 100, often 558 m). Note amplitude decay of direct P waves with increasing receiver depth before scaling.

FIG. 8. A 50 m corridor mute to depth 1115m of upgoing P and upgoing BV waves. Together with the resultant offset-dependent gather of upgoing P and upgoing BV waves.

FIG. 9. Correlation between well logs, zero-offset VSP within walkaway VSP receiver depth range (a, upgoing wave corridor stack; b, upgoing wave in two-way P traveltime applied (MMD) and fine-annual time filtering); and the comparison of offset gathers from walkaway VSP processing and synthetic seismogram from sonic and density logs for PP and PS waves (c, upgoing wave corridor stack of the zero-offset (D4 m) with offset data 15 times); d, offset gather from walkaway VSP; e, synthetic offset gather; f, stacked traces of the synthetic seismogram (resampled three times).

FIG. 10. Comparison between the amplitude at the base of the channel sand from walkaway VSP and synthetic seismograms (generated by Syngram) for PP and PS data. The amplitude of synthetic data was scaled to the average amplitude level of VSP data.