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Zero Offset, Vertical Incidence and Time-Lapse Walkaway VSP in the Eagle Ford

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Summary

A time-lapse seismic survey is one of the tools to monitor changes in the reservoir's properties over time. In this case study 2D images before and after an hydraulic fracture in the Eagle Ford formation were created from walkaway VSPs with the objective of identifying the zone affected by the treatment. The study was completed with a walkabove VSP to detect potential fractures below the wellbore that could divert the hydraulic fluid and a shear wave zero offset VSP to determine the direction of the natural fractures. This information was used in the design of future hydraulic fracture programs for wells in the area.

Introduction

To develop unconventional reservoirs, it is important to assess the success of hydraulic stimulation treatments and identify where the fluids have flowed within the reservoir. Time-lapse seismic is a geophysical tool to monitor changes in a reservoir away from well control.

A zero offset VSP (ZVSP), time-lapse walkaway VSP (WVSP) and vertical incident VSP (VIVSP) were recorded from well A in the Eagleville (Eagle Ford) oilfield, Lavaca County, Texas. The ZVSP data were acquired using P and S wave sources. The main objective was to determine the orientation of the existing natural fractures by shear wave splitting analysis (Lou et al., 2001). The WVSPs images before and after the fracture were compared to identify areas affected by the treatment performed on well B. VIVSP was processed to an image below the wellbore to detect any potential faults that could transport the hydraulic fracture fluid from the reservoir.

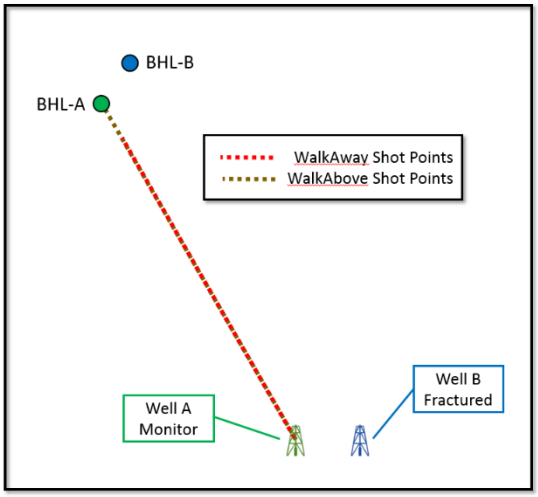

Figure 1 *Plan view of acquisition geometry.*

VSP Data Processing

The datasets recorded from the two perpendicular ZVSPs S sources were combined into a four-component dataset to perform Alford rotations (Alford, 1986, 1989; Thomsen, 1988) and determine the direction of the split fast and slow shear waves by using a waveform similarity analysis (Lou et al., 2001).

In Figure 2 these angles are shown for each geophone relative to their existing orientation. The average fast S-wave fracture orientation azimuth for the reliable levels above depth VI is 175° relative to previous geophone orientation.

The pre- and post-fracturing walkaway VSPs were acquired in May and June 2015 respectively and processed through exactly the same sequence and using the same parameters.

The post-fracture image was subtracted from the pre-fracture image to identify any differences in the amplitudes between them. The depth of the horizontal section of fractured well B is marked with a red arrow in Figure 3 and corresponds to the strongest coherent event in the time-lapse image that indicates an alteration in the rock properties (in this case acoustic impedance) caused by the hydraulic fracture.

The VIVSP was used to provide accurate transit times between the surface and borehole and an image of the subsurface underneath the borehole.

Because the VIVSP and the WVSP 2D images lay in the same plane, they could be merged into a combined image in depth as shown in Figure 4.

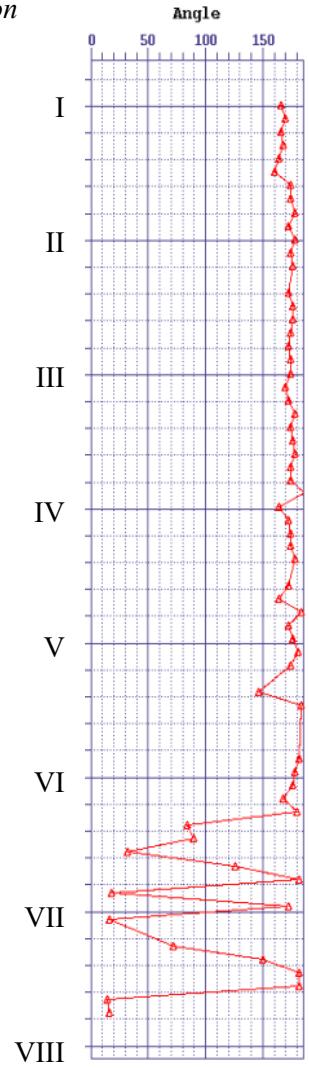

Figure 2 *Angles from shear wave splitting analysis.*

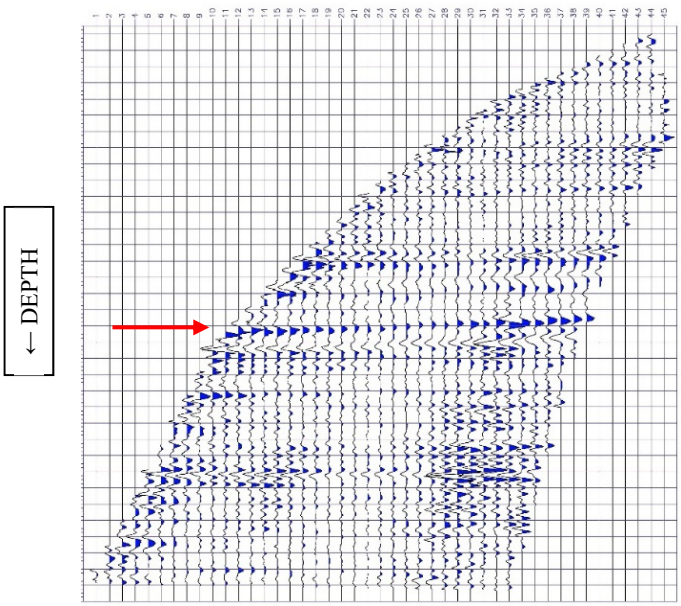

Figure 3 *Walkaway Time-Lapse image.*

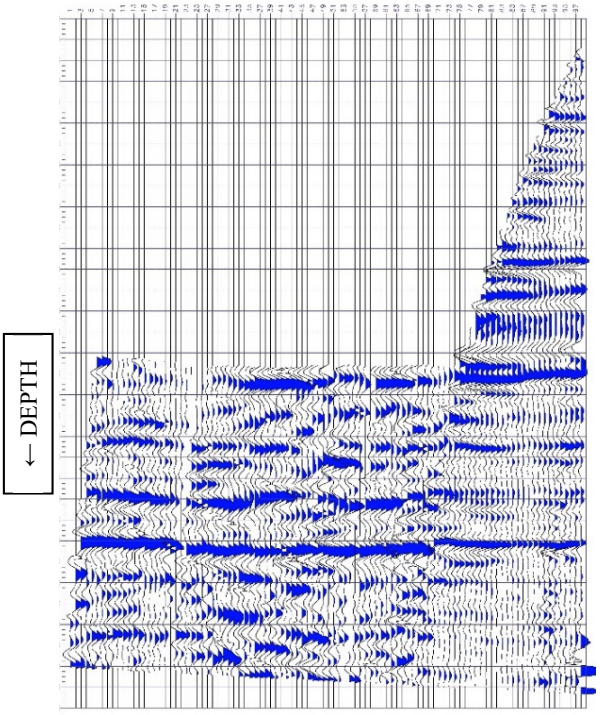

Figure 4 *Merged VIVSP and WVSP images.*

Conclusions

Shear wave splitting analysis provided valuable information about the direction of natural fracturing in the zone around the well that will help with future hydraulic fracture designs in the area.

In the time-lapse walkaway difference image, around the depth of the treated reservoir, we can see a coherent event which is an indicator of an alteration in the rock's properties caused by the hydraulic fracture in the nearby well B.

The walkabove image had a good match with the walkaway and data quality according to what was expected when using a hydrophone in a horizontal cased hole. No faults could be clearly interpreted.

References

Alford, R. M., 1986, Shear data in the presence of azimuthal anisotropy: 56th SEG Annual International Meeting, Extended Abstracts, S9.6.

Alford, R. M. , 1989, Multisource multireceiver method and system for geophysical exploration: U. S. Patent 4 803 666.

Lou, M., Zhang, Y., and Pham, D. , 2001, Shear-wave Splitting and Fracture Orientation Analysis from PS Waves - Examples From Synthetic And Field OBC Data: 71st SEG Annual International Meeting. Expanded Abstracts, 94-97.

Thomsen, L. , 1988, Reflection Seismology in Azimuthally Anisotropic Media: Geophysics, 53(3), 304-313.