Time Lapse Borehole DAS Reflection Imaging for Reservoir Engineering

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Borehole seismic data acquisition is quite efficient when using borehole-deployed DAS fiber. A relatively small number of surface seismic source points, typically between 50 and 100, recorded with DAS fiber can result in simultaneously-recorded high quality data from both the vertical and horizontal part of the borehole. The data can then be used for walkaway VSP reflection imaging and for reflection imaging using data recorded in the horizontal part of the borehole (Figure 1). In this paper we show time-lapse reflection imaging results from data recorded on horizontal DAS fiber and evaluate the observed interval velocity changes that occurred due to hydraulic fracturing and 4 months of flowback and production.

The observed P-wave and S-wave interval velocity changes can be understood through rock mechanics analysis with a focus on production-related pore pressure and stress changes. Time lapse DAS reflection images show more detailed changes in reservoir properties than are generally seen in surface seismic data due to the high spatial resolution of DAS images and generally higher frequency than surface seismic data. Combining rock mechanics analysis with time lapse DAS images can provide reservoir production details to engineers that may not be available from other cost-effective sources. We conclude from this study that relatively inexpensive borehole DAS data acquisition makes time lapse imaging a viable method of reservoir surveillance, potentially for the lifetime of a well.

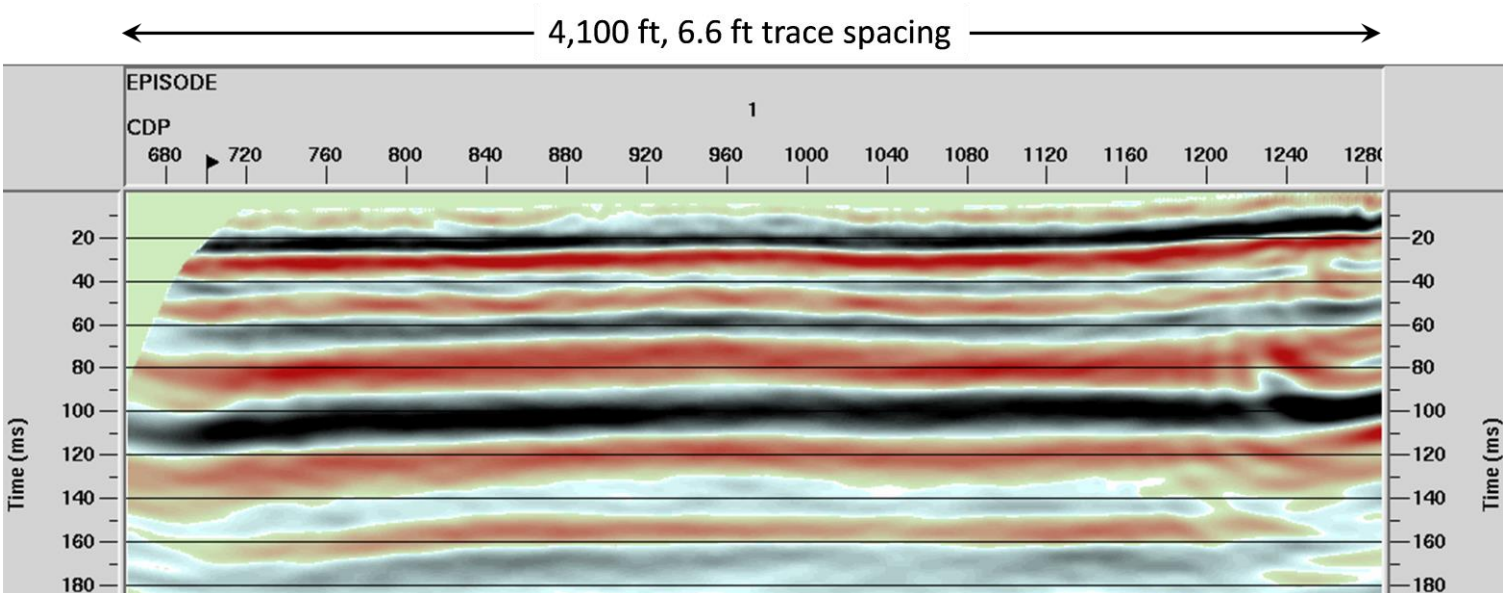

Figure 1. Seismic reflection image of a reservoir immediately below a horizontal DAS cable. This reflection image shows reflectors within 1,000 ft below a horizontal well in which a DAS cable was permanently deployed. Two-way time in milliseconds is relative to a flat datum 5 ft above the highest part of the toe-up horizontal wellbore. The field data was recorded with surface Vibroseis sources and a DAS fiber. Trace spacing of the image is 6.6 ft and the maximum usable frequency is greater than 100 Hz. The horizontal length of the image is about 4,100 ft, just a few hundred feet shorter than the horizontal extent of the well.