Using Crosswell Measurements to Enhance Velocity Model Calibration for Real-Time Microseismic Monitoring

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EXTENDED ABSTRACT

Microseismic mapping of hydraulically induced fracture networks has become the standard industry service to monitor stimulation effectiveness. One of the main sources of uncertainty in microseismic event locations is the velocity model used for processing. Typically, vertical velocities are derived from sonic logs, and horizontal velocities are calibrated using one or more sources at known locations. The most robust source for calibration has traditionally been perforation shots along the treatment well for each stage of the stimulation. This allows for calibration of the rock volume of interest for each stage. When perforations are not available, several other options may apply, including: string shots in an adjacent well, a vibrator source at the surface, ball-seating events in sliding-sleeve completions, and an early treatment event (Le Calvez et al., 2013). These methods have limitations, such as the area of imaging not covering the rock volume of interest (string shots, vibrator source), being difficult to detect in real time (ball-seating events), and having high uncertainty (early events). Furthermore, in the case of horizontal monitoring configurations, it is often the case that only a narrow depth range can be calibrated due to the monitoring and treatment wells being at similar depths.

Crosswell surveys provide information about the region between wells, much like a vertical seismic profile (VSP), but with the seismic source in an adjacent well as opposed to at the surface. Both the receivers and source are moved up the well to create dense raypath coverage over a wide range of depths and angles. Measurements of the velocity field, reflectivity, and attenuation provide crosswell products such as traveltime and attenuation tomography (e.g., Carrillo et al., 2007). Both 1D and 2D velocity models can be extracted from crosswell tomography (Leiceaga et al., 2015) and Thomsen parameters can be calculated (e.g., Washbourne et al., 2000). However, in most cases, such processing requires at least several days to accomplish; thus, using such an approach is not optimal for real-time monitoring.

For real-time microseismic monitoring, crosswell measurements can be taken prior to a fracture treatment and used in much the same manner as perforation shots to calibrate a velocity model for real-time event locations. We show two main applications for

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this method: (1) providing a versatile calibration source in cases where no perforation shots are available or other calibration sources are suboptimal and (2) extending the depth coverage for velocity model calibration in a horizontal monitoring configuration. In both cases, using crosswell sources can provide a means to reduce uncertainty in the velocity model and improve subsequent event location accuracy.

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