# Utilizing Low-Frequency DAS to Evaluate Cement Quality for Horizontal Wells

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## ABSTRACT

Ensuring cement quality of horizontal wellbore is critical for completion efficiency for unconventional wells. However, conventional methods, such as acoustic logging and external pressure gauge monitoring, often involve high operational costs and/or limited spatial resolution, making them less effective for continuous, real-time monitoring. In this study, we demonstrate that Low-Frequency Distributed Acoustic Sensing (LFDAS) measurements can be utilized to evaluate and monitor unwanted near-wellbore pressure communication resulting from poor cement quality. The field dataset was collected along a slant monitor well in the Three Forks formation, near a production well in the upper Three Forks, for cross-well strain and pressure monitoring. LFDAS data were acquired along a sensing cable permanently installed behind the casing and cemented in place (Figure 1a). Additionally, 15 external pressure gauges were installed along the monitor well for long-term monitoring. During the stimulation operation, we observed that once the hydraulic fractures reached the monitor well, high pressure rapidly propagated along the monitor well over long distances with minimal pressure loss from the fracture intersecting locations. Meanwhile, LFDAS detected strain signals synchronized with the pressure perturbation, where extensional strain rates were associated with pressure increases and compressional strain rate during pressure decreases. A strong linear correlation was found between co-located strain rate data and pressure temporal gradient derived from the gauge measurements (Figure 1d). We interpret this correlation as the Poisson effect of the cement and cable. As pressure migrated along the monitor well, likely through the de-bonding fracture between the cement and formation, increasing radial pressure was transferred into extensional axial strain, triggering LFDAS responses. Notably, this pressure communication occurred only in the heel-ward direction of the fracture hits, while it was significantly reduced in sections experienced with direct hydraulic fracture intersections. We interpret this reduction in pressure communication as a consequence of the apparent diffusivity decrease due to the pressure compressibility of the connected hydraulic fractures. Using a 1D finite difference diffusion model, we successfully history-matched both pressure gauge and LFDAS responses caused by pressure communication due to poor cement quality along the monitor well (Figure 1b). Furthermore, we quantified the diffusivity decrease in the near-wellbore region resulting from hydraulic fracture connections. During the first year of production, all pressure gauges from the monitoring well recorded similar pressure drawdowns. This was previously interpreted as an even drainage of the fracture network along the monitor well. We used the developed model to evaluate the impact of poor cement quality in the monitoring well on long-term production pressure monitoring. The model's results indicate that the communication of pressure among the gauges could significantly impact the measurement of production-induced reservoir pressure depletion; therefore, it makes evaluating reservoir drainage volume less accurate when relying solely on pressure data. This study shows that LFDAS can evaluate cement quality along monitored horizontal wells. A similar technique can be applied to evaluate cement quality for unconventional wells before stimulation, allowing completion designs to be adjusted and optimized due to the anticipated inefficiency of stage isolations.

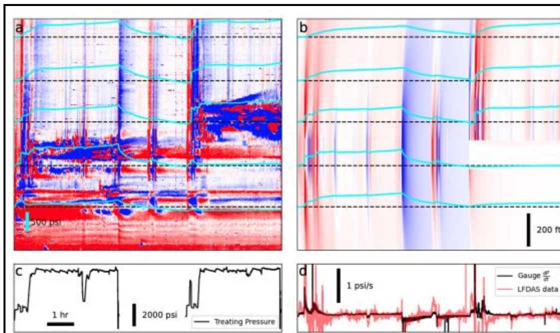


Figure 1: Comparison between field data and synthetic modeling results.
a) LFDAS data waterfall plot with pressure gauge data at the depth indicated by black dash lines.
b) Simulated strain rate and pressure responses.
c) Treating pressure during two stages of stimulation.
d) Comparison between co-located LFDAS data and gauge pressure gradient.

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