

## **Characterization and Origin of Fracture Patterns in a Woodford Shale Quarry in Southeastern Oklahoma for Application to Exploration and Development**

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The Woodford Shale is an important unconventional gas reservoir in Oklahoma. Production is by artificial fracturing of naturally fractured or unfractured rock. Therefore, understanding natural fracture networks may help in developing fracture stimulation procedures.

The main objective of this study was to document and understand the natural fracture patterns within the Woodford Shale by integrating and calibrating fractures and strata in the exposed vertical walls of a quarry using laser imaging detection and ranging (LIDAR) data, 2D seismic lines, and logs and core acquired in a well drilled behind a quarry wall. Some specific goals were to determine if the fractures align with the general strike of faulting in the study area and if the fracture sets are confined to the Woodford Shale or extend into the underlying Hunton Group.

Fracture measurements in the outcrop and LIDAR data revealed two extensional fracture sets with nearly vertical dip. Group 1 is a systematic fracture set with parallel orientations, regular spacing and mineral filling, having a median strike direction of N85°E. Group 2 is a nonsystematic fracture set, younger than Group 1, having a median strike direction of N45°E. There is no lateral lithology or bedding change, therefore the average fracture spacing is 1.2m (4ft). The present stress field in the area of study has an ENE-WSW direction that generated the fractures in Group 2, different from the paleostress that generated fractures in Group 1.

The Woodford Shale has three informal members and the Lower Woodford is not present in the area of study. There is a greater abundance of fractures in the Upper Woodford Shale than in the Middle Woodford Shale in the quarry, probably because of the former's higher content of quartz.

The 2D seismic lines imaged the Upper-Middle Woodford contact and the Woodford-Hunton unconformity surface. The faults interpreted on the seismic follow the same trend as the regional faults observed in the surrounding area.

Geologic history places regional and local structural events to have occurred after deposition of the Woodford Shale. Therefore, the Woodford Shale and the Hunton Group have the same fracture characteristics and the fractures extend through both formations in the area of study.

The information will be used as a baseline for improved understanding of fractures in the Woodford Shale to facilitate gas production by knowing fracture characteristics and in situ stress.