Field Characterization and Analog Modeling of Natural Fractures in the Woodford Shale

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Understanding the mechanisms under which shales deform is fundamental to improving exploration success in unconventional resource plays. Several outcrops of the Woodford Shale have been chosen to characterize fracture patterns at the outcrop level, and relate them to the structural regime of the study area and internal stratigraphy of the formation. The outcrops are located in the Arbuckle Mountains of Oklahoma. This region is composed of several northwest-trending folds and regional fault systems. Excellent outcrop exposures of the Woodford Shale are used as reservoir analogs. Field analysis consisted of gamma ray logs, facies descriptions and fracture characterization. Key observations include: 3rd order sea level cycles from gamma ray parasequences, five distinct organic marine facies, and abundant natural tensile fractures. Furthermore, jointing is often linear and perpendicular to bedding in brittle cherty facies, and curvi-linear and slanted in ductile mudstone facies.

The recognition of these patterns is in agreement with measurements obtained in the laboratory of the mechanical properties of the Woodford Shale. Alternating sequences of laminated mudstones are rich in organic content and mechanically ductile. Bedded chert is less organic rich, and mechanically brittle. Therefore, the Woodford Shale can be defined as an axially anisotropic material in the direction perpendicular to the bedding and an isotropic material in the direction parallel to the bedding. A simple analog model constructed with layers of Play-Doh™ and clay is used to examine the relationship between layers and the development of tensile fractures in this brittle-ductile material. The hypotheses for these experiments based on field observations are: 1) laminations in shale formations are an important control on the propagation of natural fractures along with bed thickness and mineralogy, and 2) fracture patterns in shales are broadly predictable based on the correct identification of brittle and ductile layers.