Let's Make Outcrops Recover Their Value, Understanding the Rock on the Surface for Predicting into the Subsurface: Woodford Shale Case Study, Ardmore Basin, Oklahoma*

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Abstract

Due to the high cost to acquire well cores, along with today's low-oil-price scenarios, sizeable challenges are emerging especially for unconventional reservoir characterization. Thus, detailed and integrated outcrop data tied to well log responses provide means to understand shales on the surface and give supporting notions while predicting reservoir properties into the subsurface. In this work, first we present a multi-scale approach to characterize the vertical and lateral heterogeneities of a fresh Woodford Shale Outcrop in southern Oklahoma, the exposed succession is about 350 feet thick, comprising the entire Upper-Devonian and Lower Mississippian Woodford Shale and partially the overlying Sycamore Limestone and underlying Hunton Group. About 14 detailed lithofacies were recognized, which relate direct observations and/or measurements such as color, texture, lithology, mineral assemblages and composition, bioturbation, presence and frequency of laminations and organic richness. Secondly, by cross-correlation with nearby well-logs and using clustering analysis a supervised electro-lithofacies classification was conducted, in which a statistical model was generated for permitting the prediction and propagation of up-scaled lithofacies in non-cored wells. In our case for the Ardmore Basin, the propagated model of lithofacies covers an area of about 64,000 acres and includes well-log information of 22 wells; depths of the Woodford Shale in the subsurface range from 1000 to 3500 feet. The most remarkable outcrop-to-subsurface finding of this study is a laterally continuous cyclic pattern of two end-member groups of lithofacies: (1) clay-rich, silica-poor, organic-rich, ductile lithofacies, and (2) clay-poor, silica-rich, carbonate-rich, brittle, fractured, organic-poor lithofacies. As if they were imitating a cyclic source-reservoir system, in which some lithofacies acts as an oil/gas source and others as reservoirs or fracturable rocks. Thickness and frequency of these cycles varies stratigraphically throughout the Woodford Shale, resulting in better gross intervals for unconventional resources within the Upper-Middle and Upper Woodford Shale in the Ardmore Basin.
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ABSTRACT

Due to the high cost to acquire well logs along with today’s low-oil prices scenario, logistic challenges on emerging properties for unconventional reservoir characterization. Thus, detailed and integrated outcrop data tied to well logs response provides means to understand shale on the surface and are supporting in understanding productivity reservoir properties into the subsurface.

In this work, we present a multi-scale approach to characterize the vertical and lateral heterogeneities of Woodford Shale Outcrops in southern Oklahoma. The proposed succession is divided into four main intervals, comprising the lower member or Woodford Shale, the upper member or Woodford Shale, the Sycamore Limestone, and the upper member or Arbuckle Group. Detailed rock characterization was conducted, relating rock observations and measurements such as color, texture, lithology, internal assemblages, elemental composition, organic richness, as well as geomechanical properties such as voids, rockworks, and shear strength of natural fractures.

Secondly, by cross-correlation with nearby well-logs and using statistical analyses a supervised lithofacies classification was conducted, in which a detailed model was constructed to identify the prediction and propagation of oil sand.”

The most remarkable outcrop-to-subsurface finding of this study is a laterally extended microto cryptocrystalline quartz aggregates, siliceous TOC 1.4-2.5 wt% (terrestrial influence), detrital quartz (terrigenous influence) feldspar, biogenic assemblages, elemental composition, organic richness, as well as geomechanical properties such as voids, rockworks, and shear strength of natural fractures.

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