Longitudinal Variability within a Delaware Basin, Wolfcamp Horizontal Well: Insights from Integrating Data from Borehole Image, Dipole Sonic, Drill-bit Geomechanics and Mass Spectrometry

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As the pace of horizontal drilling in unconventional reservoirs has exploded in recent years, many questions remain unanswered regarding the ability to predict rock characteristics along a lateral wellbore and which tools can be used to reduce uncertainty. This research presents the results of a comparative study aimed at characterizing lateral changes within a Wolfcamp target horizon. We integrate borehole images with dipole sonic, drill-bit geomechanics, mass spec-based organic geochemistry and hydraulic fracturing data to assess changes in rock properties, fractures and hydrocarbon composition and flow. This integrated study reveals a high-degree of longitudinal variability in rock properties that is significant to hydrocarbon recovery and improved drilling economics.

A detailed analysis was completed on 4,000+’ of image log data acquired from a horizontal well in the Wolfcamp from the Delaware Basin. Image data includes lithology, rock texture, bedding structural dip and natural and drilling-induced fracture geometry. Three distinct image zones were identified based upon changes in gamma, resistivity, structural dip, fracture type and the distribution of mass-flow and deformed beds. The boundaries between the three image zones match stratigraphic subdivisions within the target horizon that were transected during well steering. These boundaries are also notable in geomechanical and geochemical data.

Drill-bit geomechanical data correlates well with dipole sonic data and highlights the lateral heterogeneity observed from the borehole image and the mass spectrometry data. Fractured intervals correlate with higher ISIP’s when evaluating the hydraulic fracture treat-

ment data by stage. Geomechanical variability can be used to design hydraulic stimulation operations, maximize treatment efficiency and mitigate borehole stability issues in future wells.

Mass spectrometry identified 10 unique zones along the lateral, based upon distinct changes in hydrocarbon composition, inorganics, and aromatic soluble species. These data reveal changes in relative GOR, water saturation, porosity, permeability and hydrocarbon composition that correlate with changes in rock characteristics from image log and drill-bit geomechanical data. Changes in hydrocarbon chemistry in different natural fracture types could indicate connection to different sources, possibly revealing degree of compartmentalization. Defining strata by distinctive chemical signatures and linking them to geomechanics and natural and induced fracturing, can help avoid water, improve stimulation and reduce uncertainty in geosteering.

In an increasingly competitive market, low-risk / high-value data as a means of reducing reservoir quality uncertainty is key to economic success. Mass spectrometry, LWD, and seismic are capable of identifying significant lateral changes in rock and fluid properties, which can indicate the need for additional detail provided by image logs and additional open-hole logs. This study shows that these disparate data sets can be integrated to generate a synergistic product that improves the ability to predict reservoir quality.