Characterization of Unconventional Shale Gas Reservoirs using a Shale Gas Facies Expert System to Identify Lithofacies and Optimal Completion Intervals

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Unconventional shale gas reservoirs have rapidly gained importance over the past few years in North America as their percent contribution of total gas production has continued to increase. These reservoirs are rather complex and heterogeneous in terms of their geochemical, petrophysical, and geomechanical properties. It is important to identify optimal completion zones for hydraulically fracturing or horizontally completing these reservoirs in order to maximize production rates. The optimal zones are usually chemostratigraphic units or lithofacies that can be identified in shale gas reservoirs using a combination of petrographic, core, and well log analyses techniques. Identification of these lithofacies that may be unique to each shale gas reservoir is crucial for devising completion strategies. These lithofacies are typical geomarkers that usually represent eustatic changes during deposition of sediments and organic matter in these basins. Thus, they are directly related to the preservation and amount of accumulated TOC in the basin. Since gas content is related to TOC, which varies according to lithofacies, identification of these organic-rich lithofacies is important. Some lithofacies (e.g., siliceous lithofacies) are more favorable for gas recovery than others because their mineralogy and TOC content combined with their geomechanical properties make them more conducive to forming extensive fracture fairways. On the other hand, certain lithofacies (e.g., phosphatic lithofacies), based on their geomechanical properties, are fracture barriers and need to be avoided because they act as zones of fracture propagation attenuation.

A shale gas facies expert system was developed with the goal of helping operators identify optimal zones for designing selective completion strategies. This can potentially reduce fracturing expenses and optimize well productivity. The expert system first chemostratigraphically characterizes the reservoir into different lithofacies based on their geochemical makeup obtained from geochemical logging measurements. Then this system uses an integrated petrophysical reservoir evaluation approach by incorporating multiple openhole logging measurements to flag the most favorable and unfavorable zones using a simple “stop-light” approach.

We present facies models for the Barnett, the Haynesville, the Marcellus, the Woodford, and the Eagle Ford shales applied to a case study well in each of these plays to illustrate this approach.