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Diagenesis of a Tight Gas Formation: Jurassic Cotton Valley Sandstone, East Texas Basin

The Upper Jurassic Cotton Valley Sandstone is a thick siliciclastic unit in the East Texas basin. Sandstones and shales of this unit were deposited in shallow marine and fluvial-deltaic environments and exhibit progradational successions of facies. Along the eastern flank of the basin, natural gas is produced from Cotton Valley reservoirs characterized by low porosity and permeability, which have been stimulated by massive hydraulic fracturing.

Cotton Valley sandstones are generally very fine-grained, well-sorted quartz arenites and subarkoses. Principal framework constituents are monocrystalline quartz and feldspars. The sandstones have had a complex diagenetic history and are cemented by authigenic quartz, calcite, phyllosilicates, and iron oxides. The most common paragenetic sequence of pore-fill minerals was (1) development of clay coats on grains, (2) formation of syntaxial overgrowths, (3) dissolution of unstable grains followed by precipitation of phyllosilicates, (4) precipitation of calcite in relict primary and secondary pores, and (5) replacement of framework grains by calcite resulting in a poikilotopic texture. Clean coarser grained sandstones may have been cemented very early by calcite and progressed directly to stage 5 with only intermediate episodes of grain and cement dissolution.

Cotton Valley sandstones are classified by R-mode factor analysis into three groups that can be related to porosity characteristics. Therefore, the groups can be used to predict potential reservoir rock. Type I rocks are tightly cemented by quartz and calcite and make poor reservoirs. Type II rocks have a high phyllosilicate content and abundant microporosity, and may produce gas. Type III rocks have a high content of unstable grains and have well-developed secondary porosity, which can be of reservoir quality. Although there is a great overlap in characteristics of the three rock types owing to vertical and lateral inhomogeneity of the sandstones, end-member lithologies can be discriminated using log calculations of porosity and water saturation.

Depositional facies controlled the diagenesis of the Cotton Valley Sandstone. Clean, well-winnowed sands deposited in high-energy environments became tightly cemented by silica overgrowth and sparry calcite. Sands deposited in lower energy environments contained detrital clays that inhibited nucleation of overgrowths and helped preserve porosity.

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Mineralogic and Chemical Alterations During Burial in Illite/Smectite from Wilcox Shales

Burial diagenesis has resulted in structural and chemical changes in mixed-layer illite/smectite from shales of the Eocene Wilcox Group, Texas. Randomly interstratified illite/smectite high in expandable layers has been converted to regularly interstratified illite/smectite low in expandable layers with increased depth of burial. This change is reflected in the K_2O content and cation exchange capacity (CEC) of the mixed-layer clay-rich fine clay size fraction. Samples high in expandable layers have a low K_2O content and high CEC; samples low in expandable layers have a high K_2O content and low CEC. Infrared spectra suggest a progressive substitution of Al^{3+} for Si^{4+} in the tetrahedral sheets of the smectite layers and preferential conversion of iron-poor smectite layers to illite.

Concentrations of extractable cations over a 60 m (200 ft) thick shale sequence indicate that fluid has moved from the center to the margins of the sequence.

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Cotton Valley Sandstone of East Texas: A Log-Core Study

A comparison of calculations of various reservoir parameters, from logs and cores, provides guidelines for understanding reservoir evaluation in the Cotton Valley Sandstone of east Texas. The cores and logs are from the Carthage field area in Panola County. In these rocks, grain size distribution and the degree of shaliness, in addition to porosity, control permeability and irreducible water saturation. Clays in the Cotton Valley are mainly illite and chlorite. Cementation factor and saturation exponent values vary on a bed-by-bed basis; however, values of $a = 1$, $m = 1.83$, and an average value of $n = 1.89$ are acceptable for general evaluations. Sun's BITRI program was used to compute values for lithology porosity and water saturation, in good agreement with standard core and x-ray analysis. Cotton Valley Sandstone intervals with porosities less than 4% appear to be nonproductive.