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Quantitative Modeling of Secondary Migration: Understanding the Origin of Natural Gas Charge of the Haynesville Formation in the Sabine Uplift Area of Louisiana and Texas

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ABSTRACT

The Upper Jurassic (Kimmeridgian) mudstones of the Haynesville Formation in the Sabine Uplift, Louisiana and Texas, are widely considered to be a self-sourced natural gas reservoir; however, additional sources of gas may have charged the mudstones in the Louisiana portion of the uplift. Secondary migration of hydrocarbons into the Sabine Uplift from downdip, gas-generating Jurassic source rocks in the North Louisiana Salt Basin was quantitively modeled in this study. Jurassic source rocks include the Smackover, Haynesville, and Bossier Formations.

Thermodynamic equations of state were used to determine thermophysical properties of supercritical methane and water under reservoir conditions. A time-dependent derivation of Darcy's Law for pressure-driven laminar fluid flow through porous media was used to model secondary migration at reservoir conditions. This study indicates secondary migration requires approximately 100,000 yr for pore fluids to migrate through 1.0 km of carrier beds having representative petrophysical, fluid, and reservoir properties of the Haynesville Formation. As an example migration pathway, the distance from the middle of the North Louisiana Salt Basin to the center of the Sabine Uplift is approximately 96 mi (155 km). Given migration velocities over this distance, 15.5 m.y. is required for hydrocarbons to migrate from the North Louisiana Salt Basin and charge the Haynesville Formation in the Sabine Uplift. This study also indicates supercritical water is 6 times more thermally conductive than methane under reservoir conditions; however, the relatively small volumes of migrated water likely did not transfer sufficient heat for the metagenesis of methane. Based on this study, a component of natural gas charging the Haynesville Formation of the Sabine Uplift area can reasonably be explained by lateral migration and hydrodynamic flow from thermally mature Jurassic source rocks located in adjacent basins.

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