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DOCTORAL
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The Petroleum Engineering Department Presents

Characterization of Shale Sealing with Hydrogen Storage

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Location: Room 124; Tech Bridge Bldg. 9

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Abstract

Hydrogen has become a promising candidate for mitigating carbon dioxide emissions, but its low density requires large storage volumes. Porous media in the subsurface have contained methane for centuries, which suggests that they could be used for hydrogen storage with specific emphasis on ensuring integrity against leakage. Thus, in evaluating hydrogen storage, this study examined the capillary and adsorption trapping mechanisms within shale caprock. There are two principal hypotheses.

The first hypothesis posits that the safe storage pressure for hydrogen is greater than or equal to the initial methane pressure in the reservoir. Consequently, this study introduces a methodology for calculating the safe pressure and evaluates its uncertainty via Monte

Carlo simulation. Additionally, it uses an Artificial Neural Network to estimate hydrogen and methane interfacial tensions in water and brine systems at subsurface conditions. Applying the estimated interfacial tensions to the Ann Mag field in Texas indicates that the caprock can trap hydrogen at pressures reaching 8,438 psi and 10,515 psi at depths of 10,239 ft and 12,020 ft, respectively. Pressures higher than these thresholds may lead to fault slippage or fracture propagation.

The second hypothesis suggests that hydrogen permeability in organic-rich shale is at least twice that of methane because of the reduced adsorption and increased slippage effects. Molecular dynamics simulations and Knudsen criteria support this hypothesis, indicating superior transport properties of hydrogen owing to its reduced affinity for kerogen and pronounced slippage at 370 K and pressure ranging from 500 to 4,000 psi. This study also incorporates these findings into a detailed analysis of the permeability of Barnett Shale via network modeling. Finally, it determines the effective conduit size from mercury injection capillary pressure measurements to capture the differences between the respective permeabilities of hydrogen and methane.