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Enhanced Shale Gas Recovery: Insights From Gas Adsorption Experiments

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ABSTRACT

Recent progress in extraction techniques has propelled shale gas production; however, these processes remain largely inefficient. This stems from the lack of understanding of the effect of confinement on the fluids in the shale formations, which have nanometric pores, very low permeability and porosity. While primary methods of recovery provide suitable initial production rates, enhanced means of recovery using CO2 injection (Edwards, et al., 2015) may be required to sustain them. In shale, natural gas (a mixture of methane and ethane) is held freely in pores and fractures as well as adsorbed within the micropores of the organic matter (Yu, et al., 2016) and clay minerals. Understanding gas adsorption is key, as this dictates not only production rates, but also the storage potential of shale. This investigation aims to quantify gas adsorption within shale and to systematically quantify the independent contribution of both the organic matter and clay using different adsorbents. In this study, adsorption data have been measured using a Rubotherm Magnetic Suspension Balance at representative sub-surface conditions, i.e. temperatures in the range 40-80°C and in the pressure range of 0-300 bar. Shales from the Bowland area, as well as synthetic materials, such as mesoporous carbon and clays have been used as adsorbents for the gases, CO2, CH4 and C2H6. The adsorbents are characterised using low-pressure adsorption to understand the relevant structural parameters. High-pressure adsorption isotherms are obtained for the three different sets of adsorbents with the three different gases. Adsorption isotherm models, such as the Langmuir and Freundlich models, are fitted to obtain relevant parameters. The adsorption data from the shale experiment is compared to both the mesoporous carbon and the clay experiments, based on temperature, pressure, shale composition and adsorbate gas to ascertain the relative magnitudes and contribution to adsorption on shale. This yields preliminary Gas-In-Place estimates and the CO2-storage potential of the shale. References: Edwards, R. W. J., Celia, M. A., Bandilla, K. W., Doster, F. & Kanno, C. M., 2015. A Model To Estimate Carbon Dioxide Injectivity and Storage Capacity for Geological Sequestration in Shale Gas Wells. Environmental Science and Technology, 49(15), pp. 9222-9229. Yu, W., Sepehrnoori, K. & Patzek, T. W., 2016. Modeling Gas Adsorption in Marcellus Shale with Langmuir and BET Isotherms. SPE Journal, 21(02), pp. 589 - 600.