AAPG Datapages/Search and Discovery Article #90319 ©2018 GEO 2018 13th Middle East Geosciences Conference and Exhibition, Manama, Bahrain, March 5-8, 2018

In Situ NMR Measurements of Methane Isotherms in Organic-Rich Shales for Reserve Estimation

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ABSTRACT

Shale gas now accounts for more than 70% gas production in the U.S. and grows more important globally. Reliable estimation of gas-in-place (GIP) in the nanoporous shales is crucial but remains challenging. The adsorption isotherms, i.e. the pressure dependent storage of gas, in shale nano-pores can be used to estimate GIP and is also critical in predicting gas production. Traditional adsorption techniques such as the volumetric adsorption method only measures the Gibbs excess uptake, while the absolute amount of total gas in a pore system also need to include the gas in bulk state. At high pressure after 30 MPa, gas in bulk state approaching the total gas and the adsorbed gas quantity is very small; thus, traditional adsorption method estimating excess uptake and bulk gas based on various assumptions can lead to significant error. Here we use in-situ high pressure nuclear magnetic resonance (NMR) to measure the methane storage and isotherms in shale samples. This method uses the difference in NMR transverse relaxation time to separate signals from pore space and from intergranular space. This allows us to measure the in-situ absolute amount of hydrocarbons in the pore space using NMR technology of Hahn spin-echo method. Shales samples from US and from Middle East are analyzed using this NMR method and show consistent results such as the relationship with the organic content and the effect of hydration. This work demonstrates that high pressure NMR is a promising technique for the estimation of GIP in shales.