

# Water Vapor Adsorption Characteristics of Over-Mature Wufeng and Longmaxi Shales, Sichuan Basin

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## Abstract

Water is ubiquitously present within organic-rich shale and can exert an important effect on gas-in-place and gas movement in shale reservoirs. Thus, understanding the water adsorption behavior in gas shale formation is critical to optimize shale-gas productivity. In this work, the water vapor adsorption characteristics of over-mature Wufeng and Longmaxi Shales in Sichuan Basin were studied over a wide range of relative humidity (RH, 5-95%) utilizing a gravimetric method to record moisture uptake onto a dry sample over time at a specific RH condition. In addition, pore structure of these shales was characterized by field emission-scanning electron microscopy, mercury intrusion porosimetry, and nitrogen sorption isotherm. The experimental results indicate that all the adsorption isotherms are categorized as type II adsorption isotherm with a different maximum capacity for water vapor adsorption between shale samples, which is likely related to the variation of porosity and clay mineral contents. Hysteresis loops derived from water vapor adsorption curves span over the whole RH range and are pronounced in the multilayer range (approximately at 70-80% RH), which are characterized by Areal Hysteresis Index (AHI) values, derived by the ratio of the hysteresis loops area to the area of adsorption isotherm. Wufeng Shale has higher AHI values than that of Longmaxi Shale, which could be attributed to the various TOC content and pore structure characteristics. Pore size distribution curves from water vapor adsorption show the unimodal distribution of pore sizes with the largest peaks smaller than 5 nm, which may be strongly related to the interlaminar micropores in clay minerals. Mineral content (e.g., quartz and clays) and pore structure

characteristics (pore type, porosity and surface area) have great effects on the water vapor uptake in Wufeng and Longmaxi Shales. Shale samples with higher porosity and surface area can provide more adsorption sites for water vapor.