3-D Petrophysical Modeling and Gas Reserve Estimation of Marcellus Shale, Southwestern Pennsylvania, USA

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Abstract

Porosity is one of the most important fundamental reservoir properties, but it becomes very difficult to either directly measure the porosity from core samples or indirectly interpret porosity from wireline logs for shale reservoirs. A poorly estimated porosity cause high uncertainty, even error, of evaluation of other reservoir properties, such as permeability, gas saturation, and gas reserve in place of shale reservoirs. In this research, the porosity of Marcellus Shale in Southwestern PA was determined using a new petrophysical statistical model (PS model) which calculates the contribution of organic matter, clay minerals, and non-clay minerals to porosity from neutron and density logs. The PS model also needs inputs of clay volume, total organic carbon (TOC) content, organic pore percentage within organic matter (organic porosity) based on SEM images, and statistical analysis of effects of several physical properties (e.g., ratio of free to adsorbed gas, density of adsorbed gas and organic matter, hydrogen index of kerogen and clay minerals, etc.) on shale porosity. Along with determining porosity, saturation of free water, bounded water, free gas, and adsorbed gas can also be calculated using the PS model. Matrix permeability was calculated based on a semi-log relationship between porosity and permeability.The PS model was used to process about 200 vertical wells drilled through Marcellus Shale in Southwestern PA. Clay volume, TOC content, total and effective porosity, free water saturation, bounded water saturation, free gas saturation, adsorbed gas saturation, and permeability were calculated for these wells. Then, geostatistical simulation algorithms were used to construct the 3-D petrophysical

model of these properties. Finally, the gas reserve in place was calculated based on the 3-D petrophysical model. This research demonstrated a new method to evaluate shale gas reservoirs.

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