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The optimized log interpretation method and sweet-spot prediction of gas-bearing shale reservoirs

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Shale gas is one of the most important unconventional oil and gas resources, and its lithology and reservoir type are both different from conventional reservoirs [1,2]. “Where are shale reservoirs” “How to determine the hydrocarbon potential” “How to evaluate the reservoir quality”, these are some key problems in front of geophysicists. These are sweet spots prediction and quantitative evaluation. As we known, sweet spots of organic shale include geological sweet spot and engineering sweet spot.

Geophysical well logging can provide a lot of in-site formation information along the borehole, and all parameters describing the sweet spots of organic shale are attained by geophysical log interpretation[2]. Based on geological and petrophysical characteristics of gas shale, the log response characteristics of gas shales are summarized. Geological sweet spot includes hydrocarbon potential, porosity, fracture, water saturation and total gas content, which can be calculated by using wireline logs[3]. Firstly, the based-logging hydrocarbon potential evaluation is carried out, and the RBF neural network method is developed to estimate the total organic carbon content (TOC), which was proved more effective and suitable than empirical formula and ΔlogR methods [4]. Next, the optimized log interpretation is achieved by using model-searching, and the mineral concentrations of kerogen, clay, feldspar and pyrite and porosity are calculated. On the other hand, engineering sweet spot of shale refers to the rock physical properties and rock mechanism parameters. Some elastic properties including volume module, shear modulus and Poisson’s ratio are correspondingly determined from log interpretation, and the brittleness index (BI), effective stress and pore pressure are also estimated. BI is one of the most important engineering sweet spot parameters.

A large number of instances show that the summarized log responses can accurately identify the gas-bearing shale, and the proposed RBF method for TOC prediction has more suitable and flexibility. The mineral contents and porosity from the optimized log interpretation are in good agreement with core XRD experiment and other core experiments. In some polite wells of Jiaoshiba area, china, some parameters in Wufeng-Longmaxi formation are calculated, and geological and engineering sweet spots are finally determined. For the best sweet spot, TOC is about 6%, the porosity is about 8%,the volume of kerogen is about 3%, total gas content is 8m^3/t, and the brittleness index is about 90%, and the minimum and maximum horizon stress are about 30MPa and 45 MPa. Therefore, the optimized log interpretation provide an important support for sweet spots prediction and quantitative evaluation of shale gas.

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