Application of Stepwise Regression for Selecting the Optimal Log Measurements for Hydraulic Fracturing

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Abstract

Stepwise regression is used to determine the importance of different log measurements for selecting the best zones for hydraulic fracturing; its applicability is shown using data from unconventional reservoirs (Eagle Ford, Haynesville, Barnett, and a reservoir from the Middle East). The analysis begins with single log measurements (e.g., gamma ray, compressional and shear sonic, and spectral gamma ray, which can measure the radioactivity of uranium, potassium, and thorium). Other log measurements, including density, neutron porosity, and resistivity, are added to obtain more complex logging suites. These log measurements are the "inputs" for this analysis. Parameters, such as effective porosity, brittleness, total organic carbon (TOC), production index (PI), and fracture index (FI), are referred to as the outputs for the analysis.

Linear and nonlinear combinations of the inputs are investigated for the prediction of outputs. Various scenarios, beginning with the simplest cases to the most complete combination, were tested. The selection of log combinations was either based on the importance of individual logs or on industry-standard combinations (such as triple-combo and quad-combo). Correlation coefficients and root-mean-square (RMS) errors for predicting the output parameters (including FI and PI) were computed for each scenario. Based on the results, the prediction accuracies generally increased as a result of increasing the number of input logs. The analysis clearly shows the importance of using SGR (for PI and FI prediction) and resistivity (for TOC prediction) logs. Log combinations for predicting/modeling a specific parameter can be ranked based on the comparison of the reconstruction results, actual values, and correlation coefficients/errors. The most challenging properties to model include TOC, effective porosity, PI, and FI; the easiest properties to predict are brittleness and Young's modulus.