Predicting Brittleness for Wolfcamp Shales Using Statistical Rock Physics and Machine Learning

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Abstract

The ‘fracability’ for organic-rich shale formations is one of the important factors to identify shale production sweet spots. Since this property is not well understood, we utilize the mineralogical or elastic brittleness indices, as indirect indicators of fracability estimation. However, the elastic brittleness, directly calculated from Young’s modulus and Poisson’s ratio, has a weak correlation with the mineralogical index in practice. It can also give misleading results to determine well locations and optimize recovery. For this reason, we conduct statistical analyses and apply supervised machine learning to produce a more reliable brittleness prediction. Machine learning techniques can help to solve complex and nonlinear problems using large data sets. First, we conduct bivariate correlation analysis to define the most highly correlated association of rock physics properties to the mineralogical brittleness. Among the properties, we distinguish four influential factors, such as bulk density, Young's modulus, porosity, and overburden stress. Second, we derive a multi-linear regression model from four input variables based on the correlation analysis result. This regression model shows a better explanation than the traditional elastic brittleness, presenting lower RMSE and higher R2 values. Third, we apply a supervised machine learning method to these variables for a more predictive model. In this study, we use the multi-layer feedforward neural network based on the Levenburg-Marquardt algorithm. The approach finds the optimal weights for the network and has a better fit to the data than the regression model, decreasing the RMSE and increasing the R2. As a result, our combined statistical rock physics and machine learning approach can prevent the blind feeding and over-training of the networks. We conclude that machine learning techniques can provide a more accurate

estimation of shale brittleness, compared to the traditional elastic brittleness method.

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