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Total Organic Carbon Prediction from Well Logs Using the Support Vector Regression Technique

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Abstract

Determination of total organic carbon (TOC) content is very important in the evaluation unconventional reservoirs. A variety of techniques (well-log evaluation and lab measurements) has been developed to estimate it. Despite significant advances, TOC prediction still remains problematic. This paper presents a robust and inexpensive approach of predicting TOC from well logs (gamma ray, density, acoustic, and/or resistivity data) using the support vector regression (SVR) technique in conjunction of core measurements.

Generally, TOC-rich formation intervals show a higher gamma ray, lower bulk density, higher porosity, acoustic transit time and resistivity than other organic-lean layers. However, their relationship is often complex and nonlinear. This paper attempts to establish a correlation between standard well logs and TOC using the SVR technique, thereafter developing a TOC-prediction model. SVR based on the statistical learning theory is a new intelligence technique, which integrates the vast amount of logging data to predict unknown properties. Unlike the extensively used artificial neural networks, SVR utilizes the concept of structural risk minimization to avoid the over-fitting issue. It also enables select a clear set of parameters, namely the kernel function and numerical algorithm parameters, resulting in more accurate TOC prediction.

In this paper, we describe the SVR method and the comparison with other approaches. We tested our method on one field well, which contained a complete suite of logs. To demonstrate the method's feasibility and applicability, TOC were estimated separately from various combinations of different types of well logs to determine if independent analyses could generate similar results. We also performed the sensitivity analysis to determine the number of core measurements required in supervised training of TOC-prediction models. For comparison, direct determination of TOC from the downhole elemental carbon measurement was also derived as the difference between total carbon and non-organic mineral carbon. Good agreement of the results was observed between the SVR-based methods from conventional well logs and the direct determination of TOC from geochemical spectroscopy logs. The promising results stemming from this study confirm that the SVR method can be used to generate the unknown property logs (e.g., TOC or permeability) when only conventional logs and few core measurements are available.