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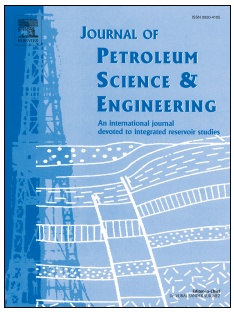

The dynamic elastic and mineralogical Brittleness of Woodford shale of the Anadarko Basin: Ultrasonic *P*-wave and *S*-wave velocities, XRD-Mineralogy and predictive models

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The Dynamic Elastic and Mineralogical Brittleness of Woodford Shale of the Anadarko Basin: Ultrasonic *P*-wave and *S*-wave Velocities, XRD-Mineralogy and Predictive Models

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Abstract–The recent advances in drilling and hydraulic fracturing technology rendered the Woodford shale of the Anadarko basin a prolific resource play producing gas and liquid hydrocarbons. Among the challenges facing improved economics, there is variable production from one well to another as well as from a completion stage to another due to the variability in facture gradient or brittleness index (BI) and the kerogen content. This investigation relies on laboratory ultrasonic P-wave and S-wave velocity in Woodford core samples to estimate BI based on the estimated elastic moduli. We modified a literature mineralogical brittleness index equation in order to take into account additional iron-rich minerals like pyrite, hematite, and iron oxides that are present in the Woodford shales, and also investigated the impact of total organic content (TOC) on the mineralogical brittleness index. Furthermore, a number of new reliable equations based on different elastic properties have been introduced in this study for the evaluation of the elastic BI, which is of significant importance in designing hydraulic fracturing in shale and tight reservoirs. In another panel of our study, the sensitivities of both mineralogical makeup of Woodford shale and elastic properties calculated –including density, acoustic impedance, Poisson's ratio, Young's modules, Lame's parameters– to the elastic brittleness index are examined. It was indicated that they have a positive effect on the prediction and can be employed in the respective predictive methods for the estimation of elastic BI. However, the analysis demonstrated that TOC has no considerable effect on mineral BI, at least in Woodford sample studied. A comparison between these newly developed predictive equations and the most commonly used methods for the prediction of elastic brittleness index available in the literature demonstrates that the new equations have a better performance in terms of both accuracy and simplicity. On comparing the BI prediction equation, with highest prediction quality "Method 1", that was developed based on ultrasonic elastic moduli with a corresponding equation based on sonic well-logs elastic moduli, Method1 was proven applicable to estimating BI based sonic frequency elastic moduli.

Keywords: Shale; brittleness index; elastic properties; mineralogy; hydraulic fracturing.