

Method of estimation brittleness for shale rocks

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The properties and response of shale are important for the petroleum industry in shale gas research. Brittleness is a common term used to describe how rocks fail and is considered a key parameter for hydraulic fracturing initiation and propagation in low permeability rock (Hucka & Das 1974, Holt et al. 2007). The aim of this study is the prediction of shale mechanical properties of the Lower Paleozoic shale rocks.

The input data include well logs with mineral content, TOC, Density, Young's modulus and Poisson's ratio and was calibrated with core lab measurements to help ensure accuracy in the estimates of mechanical rock properties. This study was performed using Petrel software from Schlumberger. Typical workflows for modelling of oil and gas reservoirs were given in Zakrevsky (2011) among others.

There are two ways to define brittleness rock index (BI). The first way is to calculate the BI in terms of the proportion of minerals (e.g. quartz, carbonates and clay content) in shales (Jarvie et al. 2007):

$$\text{Brittleness} = \frac{\text{Quartz}}{\text{Quartz} + \text{Carbonates} + \text{Clays}} [\%] \quad (1)$$

The second way to define the BI is in terms of the geomechanical properties of Young's modulus (E) and Poisson's ratio (ν) (Greieser & Bray 2007):

$$\text{Brittleness}_{\text{avg}} = \frac{\left[\frac{100(E - E_{\min})}{(E_{\max} - E_{\min})} + \frac{100(\nu - \nu_{\min})}{(\nu_{\max} - \nu_{\min})} \right]}{2} \quad (2)$$

where:

E – Young's modulus along a well path,

ν – Poisson's ratio along a well path,

$E_{\min}$ – minimum Young's modulus in the interval of interest,

$E_{\max}$ – maximum Young's modulus in the interval of interest,

$\nu_{\min}$ – minimum Poisson's ratio in the interval of interest,

$\nu_{\max}$ – maximum Poisson's ratio in the interval of interest.

Brittleness in unconventional reservoirs is controlled by mineralogy. The presence of quartz and carbonates makes shales more brittle while the presence of more clay makes shales more ductile. Shales with higher Young's modulus and lower Poisson's ratio tend to be more brittle and vice versa for the ductile rocks that are controlled by clay, calcite and total organic carbon.

The results of this study can be successfully used to make Mechanical Earth Model (MEM).

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