Predicting Fracability in Shale Reservoirs*

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Abstract

Effectiveness of fracture stimulation techniques is controlled by the heterogeneous and anisotropic nature of rocks. Sedimentologic and stratigraphic models, the interaction of present-day and induced stress, and rock material properties, which are constrained by composition and mineral distribution, nature of primary sedimentary fabric, and presence and orientation of preexisting planes of weakness, can explain rock behavior.

The Barnett Shale in the Fort Worth basin is dominated by siliceous mudstone to claystone with a clay-mineral and cryptocrystalline quartz matrix. Laminated argillaceous lime mudstone and skeletal, argillaceous lime packstone are also abundant and several other facies are less common. Facies distributions in the central and eastern part of the basin are related to their location relative to advancing shale wedges and differ between proximal, distal, axial, and fringe depositional settings.

Fracability is a function of material brittleness and ductility, which can be inferred from Young’s modulus and Poisson’s ratio. We calculate values from bulk density and acoustic slowness well-log measurements and incorporate unconfined compressive strength (UCS) and internal friction angle (IFA) strength parameters with these constants. Hand-held penetrometer and micro-rebound hammer (MRH) measurements are used to estimate UCS and IFA. These measurements are performed at a frequency and scale as to be reconcilable with well logs and detailed petrographic, fabric and TOC data and allow calibration of petrographic data and indices of brittleness and ductility with log readings.

To address the behavior of shale reservoirs, we integrate qualitative and quantitative data. These data include core and thin section descriptions, penetrometer and MRH readings, description of present-day stress field, using a stress-strength equilibrium stress polygon approach, which includes estimates of overburden stress, maximum horizontal stress, minimum horizontal stress, and direction of maximum horizontal stress. Using stress estimates, fracture orientation data from borehole image logs, and pore pressure estimates, we calculate pressures needed to reanimate favorably oriented preexisting planes of weakness in shear. This approach establishes a means of calibrating lithology with well log response, allows correlation between lithology and rock strength, and predicts fracability based on these features and the nature of the in situ stress field.
Predicting Fracability In Shale Reservoirs

Barnett Shale: West Johnson County, Texas (Location A)

Abstract

The Barnett Shale is a prime example of a complex shale system with a mixture of tight and relatively permeable intervals. This system requires detailed understanding of the mechanical properties to predict fracability and optimize production. In this study, we analyze the fracability of the Barnett Shale in West Johnson County, Texas, using a comprehensive suite of mechanical tests and analytical methods.

Setting / Introduction

The Barnett Shale, consisting of interbedded shales, mudstones, and sandstones, presents a unique challenge in terms of mechanical behavior. The interbedding of these formations results in a heterogeneous stress-strain response, making it difficult to predict fracture propagation accurately.

Supposition

We developed a predictive model for fracability based on the mechanical properties of the Barnett Shale. The model incorporates both laboratory data and field observations to estimate the stress-strain behavior and predict fracture initiation and propagation.

Production Reference (PR)

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<thead>
<tr>
<th>Location</th>
<th>Fracture-Index (FI)</th>
<th>Production-Index (PI)</th>
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<tbody>
<tr>
<td>Location A</td>
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<td>23.64</td>
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<tr>
<td>Location B</td>
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<table>
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<tr>
<th>Location</th>
<th>Site</th>
<th>Fracability vs. Production Index</th>
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</thead>
<tbody>
<tr>
<td>Location A</td>
<td>3.55</td>
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</tr>
</tbody>
</table>

Fracability Index (FI) vs. Production Index

The Fracability Index (FI) exhibits a positive correlation with the Production Index (PI), indicating that areas with higher FI values are more likely to achieve higher PI values. This relationship suggests that fracability plays a critical role in determining the productivity of a shale reservoir.

Implication

The findings of this study underscore the importance of considering fracability in the development of shale reservoirs. Improving fracability through targeted stimulation techniques can significantly enhance production efficiency and profitability.

Conclusion

This study highlights the importance of a comprehensive approach to fracability assessment in complex shale systems. Future research should focus on refining the predictive models and validating them with additional data to improve the accuracy of fracability predictions.

References


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