How Variable Can Shales Be? Lessons of Mudrock Heterogeneity

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Abstract

Facies shifts within mudrocks are often too subtle to be documented through visual inspection alone. This may give rise to the false premise that fine-grained lithologies are homogenous and should contain relatively consistent mechanical and/or reservoir properties. Using well cores from the Woodford Shale as an example, it is possible to demonstrate how these variable properties can be extrapolated into the subsurface to maximize well performance and reduce drilling costs.

Chemostratigraphy is capable of highlighting facies shifts within mudrock successions with greater confidence than is possible through visual inspection. In each sample for this study, data for 23 elements is measured using HHXRF. By using elements as proxies for facies shifts, it is possible to interpret where depositional conditions were favorable for the accumulation of organic matter. Additionally, interpreting these changing chemostratigraphic trends in a sequence stratigraphic context allows workers to resolve high-frequency cyclicity and refine sequence stratigraphic frameworks used as a means of correlation locally or across a basin.

In addition to stratigraphic variability, apparently homogenous mudrocks also contain significant differences in mechanical properties that can impact the completions process. These measurements provides a qualitative assessment of the fracability of each horizon. Using this technique, in conjunction with the stratigraphic correlations, it is possible to infer how targeted horizons will respond to well completions and plan the reservoir development accordingly.

Multivariate statistical approaches can be used to sort these data into clusters that can be inserted into reservoir models. These data are clustered into distinct chemofacies based on Hierarchical Cluster Analysis using Euclidian distances and Ward's method. Seven distinct chemofacies and four distinct hardness facies were identified using this method in this study. Using these data to help recognize mudrock heterogeneity can help plan future development target "sweet spots" while avoiding targeting horizons with low chance of economic success.