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Pore pressure prediction and brittleness index estimation from well logs for identifying sweet spots

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Summary

Resource occurrence in shale reservoir is pervasive, but commercial production from shale reservoirs requires extensive artificial stimulation. Therefore shale gas development is characterized with low geological risk, but high commercial production risk. As wellhead price for natural gas stays low, economic margin of shale gas development could be thin and early identification of sweet spot is crucial to economic success. Study from North American shale gas development suggests that a static sweet spot of high resource abundance may not be necessarily coincident with a dynamic sweet spot of high productivity. In addition to resource abundance and reservoir quality, shale brittleness and reservoir pressure could be the other two major geological factors that affect productivity. In our recent efforts of shale gas resource characterization, well logs and seismic data are used to help identify the dynamic sweet spots. This paper discusses the use of petrophysical data to estimate shale brittleness and predict formation pressure. In future plan an effort will be made to tackle the problem from the perspective of seismic integration.

In this study, we propose a petrophysical model that consists of four components, i.e., non-clay grains, clay minerals, organic matter and porosity and use it to represent the shale reservoir volume. The Eaton equation was applied to calculate the pore pressure from sonic logs, and Passey method (Passey et al., 1990) or support vector regression statistical methods (Liu et al., 2013) was employed to estimate total organic content (TOC). An inverse-distance weighted method was then utilized to evaluate mineral compositions after correcting the impacts of clay mineral and kerogen contents on the well responses. Finally the brittleness index was estimated based on mineral compositions and geomechanical properties derived from dipole sonic log for wells that data are available. The potential dynamic sweet spots could be the area with high resource abundance, high brittleness index and high pore pressure. This paper discusses the petrophysical model, mineral composition estimation using the proposed inversed distance method, shale brittleness index estimation from dipole sonic data, and the relationship between the estimated mineral compositions and rock brittleness through examples from the Devonian Duvernay Shale in the Western Canadian Sedimentary Basin.

References

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