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The Interplay of Source, Seal and Charge Loss in Unconventional Plays: An Example from the Mowry Petroleum System of the Powder River Basin, Wyoming.

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Introduction

The Mowry Petroleum System of the Powder River Basin, Wyoming includes the conventional reservoirs of the Lower Cretaceous Fall River/Lakota and Muddy Sandstones. Recently, the source rocks of this petroleum system within the Mowery Shale have been tested as an unconventional play. While these initial tests have underperformed compared to more active North American plays, previous work has delineated many essential aspects of the system providing a solid foundation for understanding the delineation and characteristics of the key elements of the petroleum system for an unconventional play.

The Mowry Shale is an organic-rich, siliceous shale deposited in the Mowry Sea of the Western Interior Basin. In the Powder River Basin, the Mowry Shale consists of distal facies primarily comprised of silt laminae and muds. Work by Schrayer and Zarella (1963) showed that TOC generally increases to the southeast within the basin and that the middle Mowry Shale is more organic rich than the upper or lower units. Momper and Williams (1984) estimate that the Mowry Shale has generated 11.9 billion barrels of oil and is overpressured.

Surdham et al. (1994) mapped clay content, maturity and log responses to create detailed maps of overpressured zones. An important finding of the Surdham et al. work is that the sandstone bodies encapsulated in the Mowry Shale can be normally-pressured, overpressured or underpressured depending on the presence of seal to the generative cell. In addition to the consideration of seal interfaces, a regional comparison of maps by Surdham et al. shows that an increase in pressure within the Muddy Sandstone is roughly coincident with a regional decrease in shale overpressure from south to north within the basin.

In this presentation we present regional work to understand the interplay between source, carrier beds and the complexities of seal to highlight the variability of an unconventional play within the Mowry Petroleum System.

Theory and/or Method

Our work in this project uses an integrated approach to understanding regional pressure variation in the Mowry system. We begin by mapping log facies within the Mowry-Muddy system and creating a series of isopach maps. The depositional settings and sedimentology of the log facies are elucidated by core descriptions and geochemical analyses including pyrolysis and XRD.

Plugs were taken from critical interfaces and facies in a vertical orientation and flow-through permeability was measured on the EGI “Shale Interrogator” system using decane as the hydrocarbon fluid and reservoir temperature and pressure in the plug confining system. The shale facies are quantified as baffles and seals and compared to the regional thicknesses to understand their regional influence on the observed pressure cells.

Finally a basin model was created to assess generated volumes and potential pressure creation due to the regional interplay in transformation, richness and kerogen quality with the seal capacity of the generative cell.

Conclusions

The geologic influences on the Mowry Petroleum System’s generation and retention of hydrocarbon are complex. Variable heating within the basin also appears to be a principle factor in the pressure cell variabilty. Mapped basement terrain changes coincide with areas of increased generation. The regions of increased generation are in some cases correlated to overpressured zones within the sandstones and nearly always correlated to overpressure in the shales.

A final complication on the system is the expulsion efficiency of the cappilary seal that allows migration of hydrocarbons updip in the Muddy Sandstone outside of the generative pod of Mowry source rock. The variability in thickness of sedimentary facies as well as the juxtaposition of facies in the overall architecture of the play seems to exert some level of control on the pressure cell. Connectivity of carrier facies acting as a “thief” zone for pressure within the basin and fluids in the basin are another important factor to consider for determining the viability of the unconventional play.

References

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