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Deciphering the Upper Cretaceous Second White Specks self-sourced reservoir rock. Insight from organic geochemistry and basin modelling

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Summary

The Upper Cretaceous Second White Specks (Second White Specks (SWS) and Upper Belle Fourche (UBF) alloformations) is an enigmatic self-sourced reservoir rock in the Western Canada Foreland Basin endowed with a large amount of light oil in place (Osadetz et al., 2010). Lack of production repeatability, however, has hampered its consideration as an economically viable resource play. The expected ultimate recoverable oil and the flow rate can vary by several orders of magnitude on local scales (e.g., among adjacent wells) and regional scales (e.g., productive vs. non-productive regions along the play fairway). The causes of these variations are not well understood. One potential explanation for such unpredictable performance is heterogeneous distribution of oil charge in the source rock. Therefore, this study investigates the thermal history and geochemical properties of the organic matter to assess lateral variability in generated hydrocarbon from the Second White Specks in the foredeep section of the basin. The purpose is to contribute to the understanding of this puzzling shale play and reduce the exploration and production risk.

Method

The methodology consisted of the characterization of the organic matter integrating organic geochemistry and basin modelling in seven wells. Organic petrography and Rock-Eval was used to determine paleoenvironmental conditions, kerogen characteristics and thermal maturity. These results, along with a novel post-Eocene exhumation model (Aviles and Cheadle., 2016), were integrated into 1-D and 2-D basin models. The 1-D models depict the burial and thermal history in each of the seven wells. The 2-D basin model portrays the lateral variation in thermal maturity and hydrocarbon generation (transformation ratio) in a NE to SW cross-section.

Results

The geochemical analysis shows that the SWS and UBF are rich in organic matter with high generation potential. The concentration of organic matter (TOC) decreases westward in the basin because of increasing thermal maturity and hydrocarbon generation. However, it was observed TOC enrichment at the center of the basin suggesting local enhanced preservation conditions. The kerogen is type II, with a maceral assemblage dominated by liptinite with secondary inertinite and vitrinite.

The source rock in most wells in the traditionally considered “oil window” fairway of the Second White Specks is thermally mature and basin models suggest that hydrocarbon generation started in Late Paleocene. Nevertheless, two wells show anomalous characteristics that suggest local hydrocarbon charge variability. In one well the organic matter is immature despite being located in the oil window fairway, and in close proximity to a thermally mature well. In another well geochemical parameters suggest the organic matter is mature. The basin models, however, revealed that variations in heat flow delayed the onset of hydrocarbon generation, resulting in a low kerogen conversion.

Conclusions

This research affirms there are lateral variation in thermal maturity and kerogen conversion that impact the amount of hydrocarbon generated present in the Second White Specks (SWS and UBF alloformations) self-sourced reservoir rock and that may be available to be produced.
Understanding the causes of these maturity anomalies is important because these wells are in a Second White Specks light oil development fairway. These results challenge the enduring idea that the Second White Specks shale play extends uniformly across an “oil window” area that has been defined by low resolution maturity data.
These findings highlight the necessity for further detail investigation to understand the factors controlling the maturity and hydrocarbon generation and the potential consequences to hydrocarbon production.

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