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Interaction Between Formation Temperature, Oil Viscosity and Production

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Summary

A significant proportion of oil production in the Western Canada Sedimentary Basin is relatively high viscosity oil. Horizontal drilling has led to the recent exploitation of significant resources in the Clearwater and other heavy and medium oil plays.

Every play has critical controls on the production rate and, thereby, the return on investment. Darcy's Law dictates that production rate is primarily controlled by two factors; pressure and viscosity. In the case of heavy oil plays, in situ viscosity is the primary determinant of production. Techniques for reservoir characterization (i. e.: pressure, reservoir height, porosity, oil saturation) are well understood. Methods to predict in situ viscosity are less well established.

Applying a GIS based process incorporating geothermics and oil analysis data allows for the estimation of in situ viscosity. This presentation will provide a review of this workflow for the Clearwater and Montney plays accompanied by production summaries for wells with varying in situ viscosity.

Theory / Method / Workflow

Darcy's Law describes rate of flow (Q) through porous media, where

- Q = $kA(\Delta\rho)/(\mu L)$
- k = permeability (mD)
- A = cross-sectional area
- μ = viscosity (cp)
- $\Delta\rho$ = pressure drop
- L = Length over which pressure drop is occurring

In heavy oil plays, k is relatively high and pressure is close to hydrostatic. As a result, the primary variable in oil production is viscosity. Viscosity strongly correlates with reservoir temperature. Standard oil analysis data provides a relationship between viscosity and temperature for each sample. As can be seen in Figure 1, viscosity vs. temperature curves can vary considerably across a play area. Oil analysis and temperature data are, however, relatively sparse and discretely distributed compared to other data types for understanding reservoir conditions.

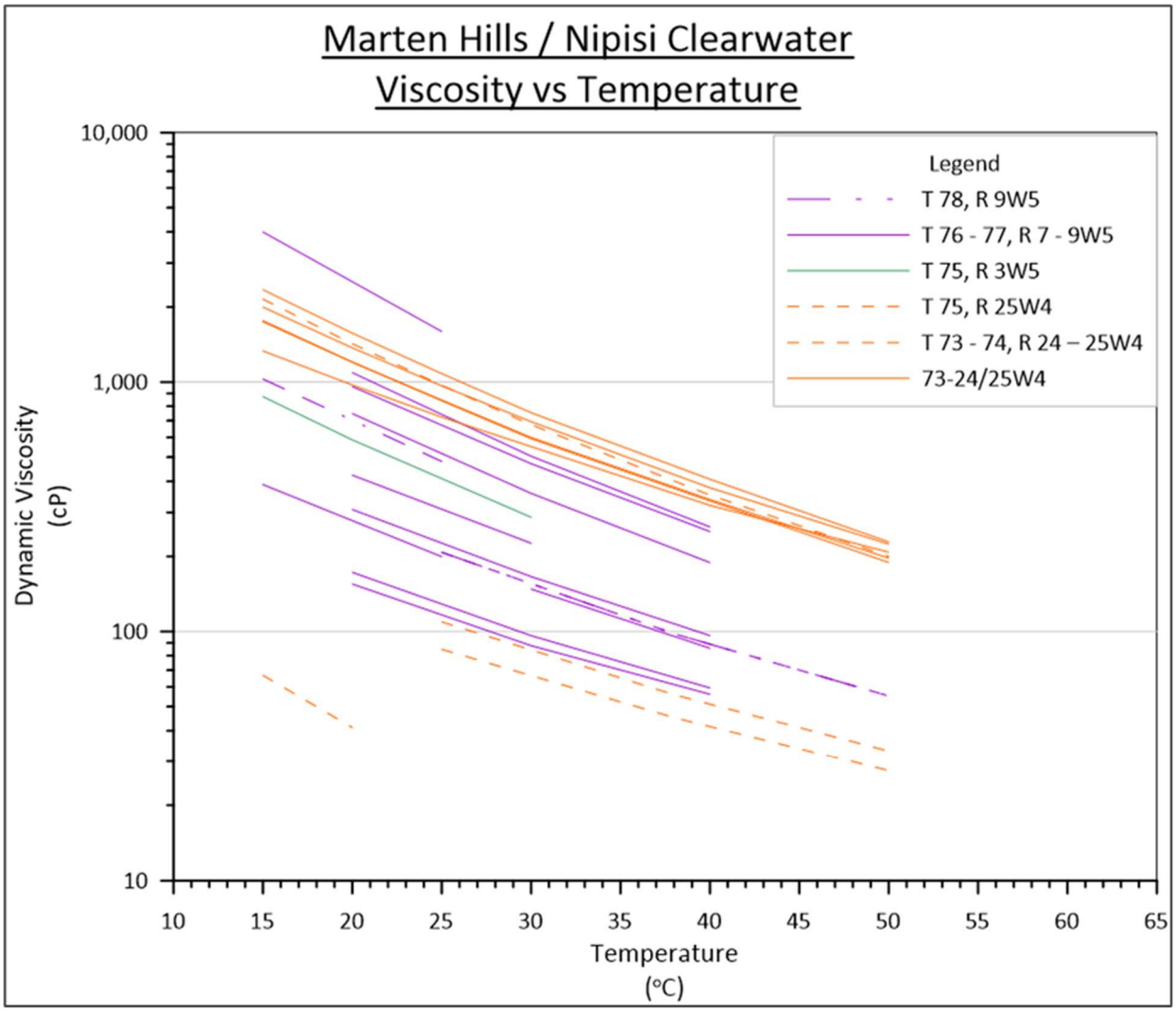

Figure 1: Viscosity vs temperature curves for a selection of Clearwater oil pools.

Formation isotherms can be calculated where geothermal gradient, surface temperature and formation depth data are available. The geospatial grids for isotherm can then be convolved with extracts from oil analysis data to calculate and map in situ viscosity data.

Results, Observations, Conclusions

Wells with a lower calculated in situ viscosity demonstrate a higher oil cut compared to wells with higher in situ viscosity. Migration appears to have been a significant factor in the observed variation of viscosity in analyzed oil samples. The understanding of these trends will be enhanced by additional sampling along the Clearwater and other play trends.

The development of a robust and detailed geothermal gradient dataset and surface temperature data allowed for the generation of accurate isotherm grids when combined with formation depth data. This temperature data was then available for use to determine in situ viscosity.

Given the variable nature of viscosity vs temperature trends, maximizing the number and distribution of oil analysis data is important, as is the close supervision of the conditions at which the samples are tested.

Novel/Additive Information

This process provides an innovative GIS based process to incorporate all available data to understand the critical variable in maximizing oil production rate in heavy oil plays from horizontal wells with comparable standard reservoir characteristics. Understanding the in situ viscosity trends will assist in maximizing value from medium to heavy oil plays.