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A Least Square Non-Parametric Discovery Process Model for Assessing Resource Potential in Plays with Mixed Conventional qnd Unconventional Resources, Application Examples from Colorado Group Oil Plays, Western Canada Sedimentary Basin

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Abstract

The middle Cretaceous Colorado Group of the Western Canadian Sedimentary Basin consists predominantly of mudstone deposited during major marine inundations interspersed with relatively thin sandstone and conglomerate beds. The Colorado Group petroleum system, containing a large portion of the light-medium oil and natural gas reserves within the Middle Jurassic to Cretaceous foreland basin succession, is a supercharged, high efficiency, high impedance petroleum system. Where it is mature, the source rocks of interspersed marine mudstone generate large volumes of liquid hydrocarbons. Some of the oils are trapped in conventional reservoirs, and part of the oils form oil pools in tight siltstones or mudstones. Therefore, petroleum plays in this system are typically oil and gas plays with mixed conventional and unconventional resources. Oil and gas reserves are found in discrete conventional pools of high porosity-permeable sandstone reservoirs as well as in continuous extremely low porosity-permeability "tight" or "shale" reservoirs. Assessing the resource potential and characterizing the resource distributions in a mixed type play or unconventional resource play has become a challenge for both government and the petroleum industry. These challenges must be adequately addressed to ensure efficient conversion of resource potential to recoverable reserves and petroleum supply.

In our recent methodology study, we have developed methods that can be used to assess petroleum resource potential in a mixed play with conventional and unconventional petroleum resources. The least square non-parametric discovery process model is one of the methods developed. This non-parametric model allows visualization of goodness-of-fit between the modeled creaming curve and observations, and produces a parameter map providing visual guidance to assessors for selection of alternative parameter sets which could generate results more consistent with the geological and geophysical constraints. Most importantly, the non-parametric model permits more flexibility in the shape of pool size distribution and can handle problems of non-single-mode distributions arising from mixed populations of petroleum accumulations in

conventional and unconventional reservoirs within the same geographically restricted stratigraphic unit. The outputs of the method consist of:

a) A predicted creaming curve overlain by the observations demonstrating the goodness-of-fit between prediction and data;

b) A map showing the goodness-of-fit as a function of parameters, from which alternative parameter sets can be chosen if the existing solution is not consistent with the geological understanding or the geological/geophysical constraints, and

c) Predicted remaining pools grouped by size classes for economic analysis and exploration planning.

Applications of the least square non-parametric discovery model to oil plays in the Colorado Group suggests that this method is useful in cases of mixed oil pools with distinct size characteristics due to differences in reservoir types and hydrocarbon charging characteristics in combined conventional and resource plays. The results of the assessments from five major oil plays in the Colorado Group suggest that there is still a great potential of undiscovered oil resource in this petroleum system. More than 1800 oil pools with size greater than 0.064 $x10^6$ m^3 (0.4 million barrels) oil in place and a total remaining potential of 307 $x10^6$ m^3 (1.9 billion barrels) oil in place are expected.