Optimized Montney Oil & Gas Recovery using Surfactants – From Matrix Pores to Proppant-Pack Fractures

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Introduction

To facilitate oil and gas recovery from the volatile oil (VO) and gas condensate (GC) windows of the Ovintiv Dawson and Pipestone area of the Middle and Lower Montney, Figure 1, detailed laboratory work was conducted to determine if the use of surfactants could modify fluid-fluid and rock-fluid interactions in Montney pore/fracture space to improve hydrocarbon mobility. Various surfactants and friction reducers are tested under reservoir conditions using native fluid re-saturated core plugs and the addition of completions fluids.

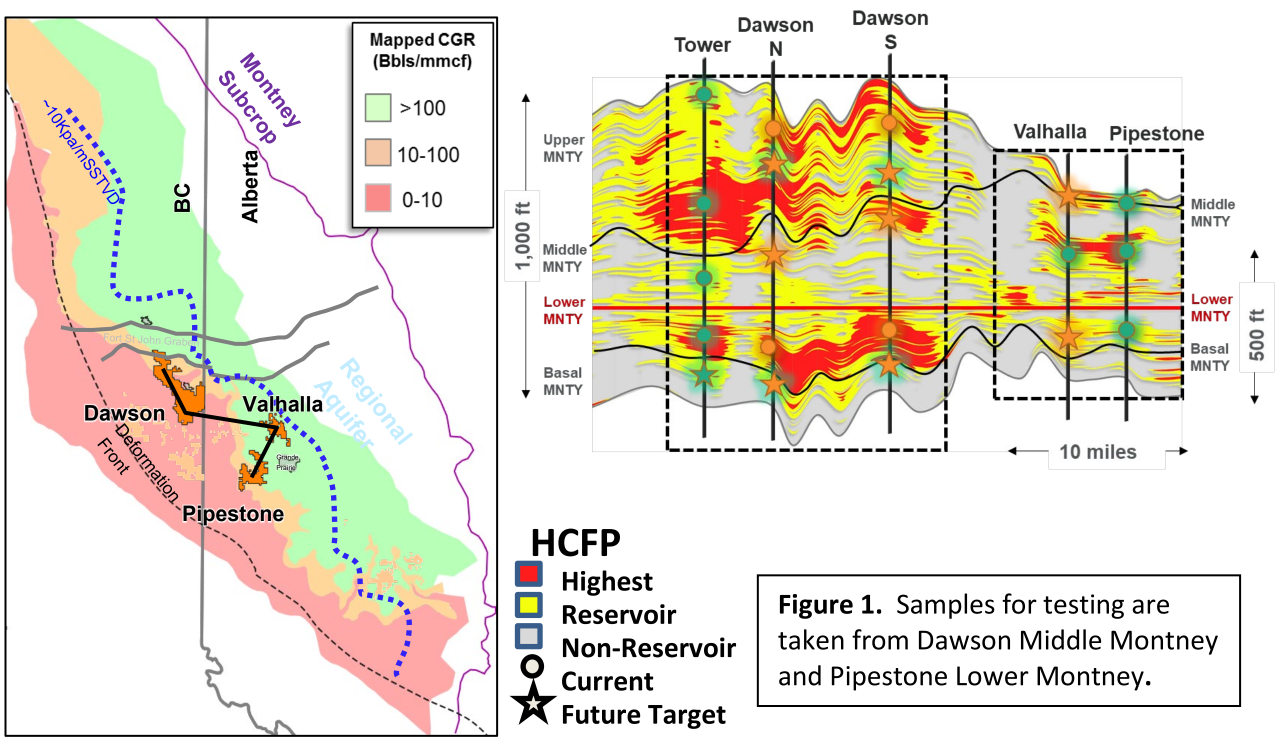

Figure 1. Samples for testing are taken from Dawson Middle Montney and Pipestone Lower Montney.

Samples and Methods

Montney core plugs in the VO & GC windows were taken from core in the Dawson and Pipestone area and re-saturated and aged with native fluids from produced wells. With respect to the VO window (Stage I), oil recovery is measured in high-temperature Amott cells to compare various surfactants and friction reducer mixtures, Figure 2. Fluid compatibility testing is conducted with fluids used in completion operations with the addition of various surfactants and friction reducers to measure cloud point (CP) and ensure chemical stability at reservoir temperature. Fluid-fluid and rock-fluid interactions are characterized through measuring the dynamic interfacial tension (IFT) and static contact angle (CA) between various completion fluid designs and reservoir crude oil (and reservoir rock in case of CA). These tests aimed at identifying superior surfactants with the efficacy to reduce the IFT between the fluid pairs and reverse the native wettability of the reservoir rock, thereby enhancing spontaneous imbibition of fracturing fluid into and oil recovery from the pore matrix.

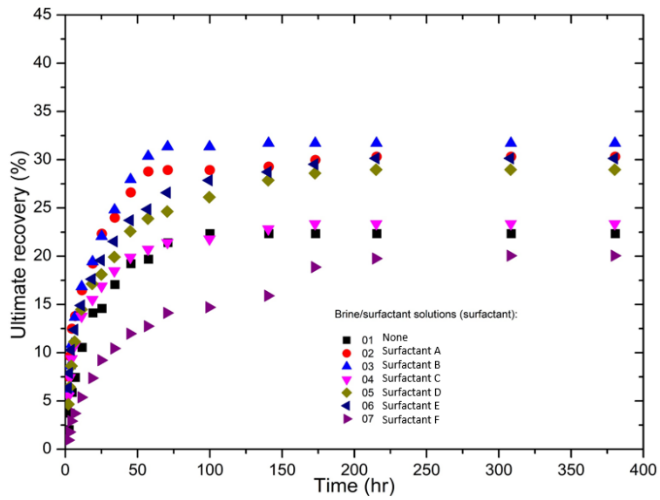

Figure 2. High-temperature Amott cell testing and oil recovery to determine superior surfactants.

Concerning the GC window (Stage II), fluid compatibility (e.g., CP) and fluid-fluid interactions (i.e., dynamic IFT) are characterized to identify a stable superior surfactant that can reduce the interfacial tension between the fracturing fluid and reservoir hydrocarbon gas mixture. The potency of the superior formulation in mitigating water blockage issues in proppant-packed fractures and the rock matrix are then evaluated through two-phase core-flooding experiments in intact and fractured reservoir rocks under high temperature and pressure (in situ Montney reservoir conditions). In each case, measurements include changes in initial water saturation (S_{wi}), i.e., blocking water content, and end-point effective gas permeability at S_{wi} in samples treated with and without the superior surfactant. Post experiments, the proppant-packed fractured samples are imaged at high resolutions (5-10 μm) using a micro-CT scanner to characterize geomechanical deformation (dis-integration and/or embedment) of proppants under elevated stress conditions and identify any potential scale formation in the proppant pack pore space.

Results and Conclusions

Stage I experiments in the Middle Montney VO window have pointed to several surfactants that performed well under reservoir temperature to liberate higher oil recovery than the base completion fluids. Measurements of contact angles and interfacial tension show the potential for enhanced oil migration with lowering contact angles by half and decreasing IFT by 75% with no measurable precipitates forming. Results point to a change in the native wettability of the Montney from weakly water wet to a strongly water wet state to liberate more oil. Early results in Stage II experiments in the Lower Montney GC window, show a similar drop in IFT (but to a lower extent) with no precipitates. Water blockage results are still pending as of this writing, but are currently being conducted. These experimental trials have pointed to several products that could potentially enhance hydrocarbon recovery and will be deployed to field trials in 2023.

Novel Information

Piri Technologies at the University of Wyoming have been engaged to perform these experiments due to their unique lab set-up which allows for experimental procedures to be conducted on restored core samples under reservoir pressures and temperatures. Advanced two-phase, flow-through tests in propped fractures and ultra-tight rock matrix as well as 3D micro-CT imaging are novel techniques that help understand pore-scale fluid displacement/migration mechanisms and effects of water blockage and deformation on overall conductivity of fractured systems.