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A CHOPS case study of a discovery of highly viscous heavy oil on the Poundmaker Cree Nation in Saskatchewan, Canada

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Summary

In 2012, a new pool wildcat (NPW) was drilled, targeting a horizontal wellbore, into the oil leg of a Cummings sand structure on the Poundmaker Cree Nation in southeast Saskatchewan. The NPW well discovered a heavy oil field that contained 77 million barrels of petroleum initially-in-place. Heavy oil producers in the area use a process known as cold heavy oil production with sand (CHOPS) to produce heavy oil and associated water in heated tanks; the heavy oil and water are then trucked to sales points and disposal sites, respectively. Crucial to the success of the project was answering the question regarding the viscosity of the heavy oil in the reservoir. Would the oil cold-flow using conventional means? It was determined post-drilling that the heavy oil at Poundmaker was a highly viscous heavy oil. Production testing of the well showed the well cold-flowed conventionally without enhanced recovery methods or sand. Recent advances in cost-effective improved recovery methods, such as polymers and surfactant-based chemistries, were successfully tested to enhance heavy oil recovery and reduce water production.

Introduction

The Poundmaker Cummings sands prospect was identified using seismic methods in the 1980s, and drilled using vertical wells in the mid-1990s and again in the early 2000s. Attempts to drill stem test and flow test the Cummings sand heavy oil reservoir in the early vertical wells proved inconclusive, and the oil viscosity data was either lost or never recorded. In September 2012, a NPW horizontal well drilled into the Poundmaker oil field cold-flowed highly viscous heavy oil during a two-month production test. Understanding the detailed reservoir geology and incorporating cost-effective improved recovery methods were imperative in solving heavy oil viscosity issues in the field. Recent advances in polymers and surfactant-based chemistries helped to increase the mobility of high-viscosity heavy oil, which had been previously immobile in the reservoir. A geo-tailored horizontal well configuation, known as a J-well, and slotted liner placement also proved effective.

Theory and/or method

Understanding the geology and reservoir attributes of the Poundmaker heavy oil field Cummings sand was the single-most important element in unlocking CHOPS. Analysis of mature field analogs and well production, and study of drill core and wireline log data also proved valuable tools in understanding the Poundmaker Cummings heavy oil prospect. The presentation will focus on learnings from grain-size analysis of unconsolidated Cummings sandstones, and implications for slot size in slotted production liners for promoting CHOPS. The J-well wellbore configuration of the horizontal leg provided many benefits. With the heel of the J-well at the bottom of the reservoir (above the water line) and the wellbore inclined from the heel, the toe of the wellbore was several metres higher at the heel. The J-well cut up through the geological heterogeneities in the reservoir, targeting more valuable lower-viscosity top oil, while enhancing gravity drainage. Blank production liner was used in the heel, and the remainder of the horizontal 0.025-inch slotted production liner was used.

It was determined post-drilling that the viscosity of the oil was ~43,000 cPs (10API) at reservoir temperature. Reservoir qualities of the Cummings sand were anomalous and extraordinary, with porosities ranging from 32% to 34% and permeabilities ranging from 6,000 md to 8,000 md. Reservoir temperatures were 26°C to 28°C. Several surrounding mature heavy oil anolog fields have produced tens of millions of oil barrels at extremely high water cuts and production rates. Recovery factors of mature analog fields were determined to be in the range of 4% to 6%.

The most significant technical risk was cold-flowing a highly viscous heavy oil reservoir using conventional means (PC pumps). Conventional wisdom holds that oil viscosities over a few thousand centipoise make the initiation of cold heavy oil production challenging, if not impossible. At Poundmaker, anomalously high permeabilities, porosities and reservoir temperatures were the main reasons why a highly viscous heavy oil cold-flowed. Lab testing of the highly viscous oil using several cost-effective polymers and surfactant-based chemistries to improve recovery methods proved successful in enhancing oil production. For example, batch injection field testing using a surfactant-based chemistry resulted in increased oil production from an estimated 10% oil cut to one between 40% and 50%.

The Poundmaker oil field discovery and subsequent production of highly viscous heavy oils were the result of diligent geoscience, perseverance, ingenuity and the fearless application of recent advances in enhanced heavy oil production technologies.

Conclusions

The Poundmaker oil field is a case study for CHOPS production in highly viscous heavy oil reservoirs. The Poundmaker oil field cold-flowed highly viscous heavy oil. Cost-effective improved recovery techniques were used to enhance oil recovery. Understanding the geology and reservoir parameters, as well as implementing cost-effective methods to enhance oil recovery are the keys to conducting a successful and profitable CHOPS project in highly viscous heavy oil reservoirs.

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