Can We Translate High Oil Recoveries from Bakken Rocks in the Lab Using Associated Natural Gas and CO_2 to the Field?

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Abstract

The Bakken contains up to 900 billion barrels of oil, but present methods only recover a few percent of the potentially-available oil (Kurtoglu, 2013, SPE 168915). In the lab, CO_2 is capable of nearquantitative recovery of oil from middle Bakken rock, as well as from upper and lower Bakken shales with sufficient exposure times and rock surface area (Hawthorne, 2013, SPE 167200). Unfortunately, Bakken field demonstrations are lacking, partially from limited readily-available CO_2. In contrast, more than 1 Bcf/day of natural gas is produced in the Bakken, with ca. 30% flared because of insufficient infrastructure (North Dakota Industrial Commission, November 2013). Utilizing this gas for EOR could be a practical alternative to flaring. Our investigations seek to provide experimental data on the potential to use natural gas as compared to CO_2 for EOR in the Bakken.

Bakken crude oil minimum miscibility pressures (MMP) were determined for methane and CO_2 by a capillary rise method (patent pending) and show that methane MMPs are higher than CO_2 MMPs. For example, MMPs for a "live" crude increased from 3180 psi with CO_2 to 5330 psi with methane, a pressure still low enough to be attained in the Bakken.

Methane, 85/15 methane/ethane, and CO_2 were then used to expose upper, middle, and lower Bakken rocks and determine the oil recovery rates under reservoir conditions (5000-6000 psi, 110°C). The experimental system mimics the fracture flow expected to dominate in unconventional hydraulicallyfractured reservoirs, rather than the "flushing" (fluid flow through the rock) mechanism that dominates EOR in conventional reservoirs. These experiments show that, similar to CO_2, natural gas is capable of >95% oil recovery from the low-permeability middle Bakken, as well as moderate recoveries from the very-low-permeability upper and lower shales. Recoveries are controlled by exposure times and exposed rock surface area. Additional experiments are being performed to better understand the mechanismscontrolling oil recovery, with the goal of translating high oil recoveries in the laboratory to realistic increases in reservoir recovery factors.

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Dr. Steven B. Hawthorne's principal areas of interest and expertise include environmental chemistry and analysis and supercritical and subcritical (superheated) fluid extraction and reactions. Recent projects focus on investigating the processes controlling CO_2 storage and enhanced oil recovery in unconventional reservoirs, the development of analytical chemical methods to determine the bioavailability and fate of environmentally aged pollutants, and the study of the chemical behavior and practical uses of supercritical and superheated fluids including carbon dioxide, natural gas hydrocarbons, hydrogen sulfide, and water. These investigations have led to more than 200 peer-reviewed publications, national and international awards, and three patents.