Enhanced Oil Recovery in Unconventionals

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Abstract

In recent years, the greatest expansion in North American oilfield development has been in unconventional tight oil formations (<10 mD permeability), where fluid flow pathways are dominated by natural and artificially induced fractures. The Bakken Formation in the Williston Basin is an unconventional tight oil resource with oil in place estimates ranging from 300 billion barrels (Bbbl) to 900 Bbbl of oil. However, primary recovery is typically below 10%. The characteristic low porosity and low permeability of the Bakken Formation will present challenges to CO_2 injectivity, oil recovery, and storage capacity. Application of the U.S. Department of Energy methodology for estimating CO_2 EOR and storage capacity in the Bakken Formation in North Dakota suggests that the Bakken holds a potential storage resource of 1.9 to 3.2 billion tons of CO_2, which could yield 4 to 7 billion barrels of incremental oil. However, the DOE methodology was developed with conventional oil reservoirs in mind, and many of the assumptions upon which that methodology is based (especially with respect to fluid phase behavior and sweep/storage efficiency) may not be as directly applicable to tight oil formations due to their unique porosity, permeability, and organic matter characteristics. The widespread exploitation of tight oil resources is also a relatively recent development, thus the current level of knowledge of mechanisms and factors affecting both oil production from, and CO_2 behavior in these unconventional tight formations is relatively low when compared to knowledge of conventional reservoirs. With these issues in mind, since 2014, a research program to evaluate the potential for storage of CO_2 for greenhouse gas emission mitigation and attendant CO_2-based EOR in the Bakken has been conducted by the Energy & Environmental Research Center (EERC) at the University of North Dakota. The ultimate goal of the program is to provide stakeholders with new knowledge that can be applied toward the design and execution of a pilot injection and production test in a Bakken reservoir. Routine and advanced characterization techniques were applied to samples of the Upper and Lower Bakken Shales, as well as the non-shale lithofacies of the Bakken Middle Member, to develop a detailed understanding of the pore throat networks of the different lithofacies at scales ranging from macro- to micro- to nanoscale. Laboratory-scale experiments were also conducted to examine the ability of CO_2 to permeate plug samples of the various lithofacies of the Bakken and mobilize hydrocarbons from those samples. Simulation modeling of the plug-scale experiments was also conducted to examine the relative effects of different rock characteristics and mechanisms on hydrocarbon mobilization. Recent EERC research efforts have also examined the potential effectiveness of rich gas as an injection fluid for EOR. The results of those activities indicate that ethane and methane-ethane mixtures can have similar or lower minimum miscibility pressures as compared to CO_2 and may also mobilize oil from Bakken plug samples under reservoir conditions.

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