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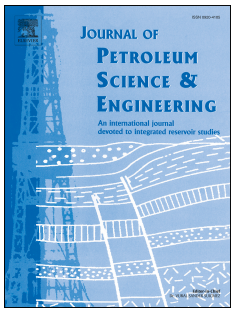

Experimental and numerical investigation of tertiary-CO_2 flooding in a fractured chalk reservoir

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Experimental and numerical investigation of tertiary-CO_2 flooding in a fractured chalk reservoir

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Abstract

This paper describes tertiary CO_2 recovery mechanisms observed in two distinct core flooding experiments. In both experiments, water flooding followed by CO_2 injection into an outcrop chalk with matrix-fracture system at reservoir conditions. The objective of this paper is to study the main mechanisms that control the rate of oil recovery during tertiary-CO_2 flooding. A series of experiments as well as compositional numerical simulations have been carried out to evaluate the efficiency of the process.

In the first experiment (Exp-1), the fractured core is initially saturated with North Sea Chalk Field (NSCF) stock tank oil (STO) and the connate water. Whereas in the second experiment (Exp-2), the core is saturated with NSCF live-oil and the connate water. Once the reservoir condition is established (258 bara, 110 ºC), sea water is injected from the bottom of the fracture and the oil is recovered from the top. Once no more oil recovery is observed, the water flooding (WF) is stopped. A "shut-in" period follows which allows preparing the rig for the CO_2 flooding (CF). Right after the "shut-in", CO_2 is injected from the top of the fracture and the oil is produced from the bottom. A compositional reservoir simulator with a tuned equation-of-state (EOS) is utilized to model the experimental work. An automated history matching algorithm is developed to fit the experimental data of WF and CF periods.

Good agreement between the model and experimental data is obtained. We observe a strong impact of hysteresis on fitting the fluid production during CO_2 flooding in Exp-2. The sensitivity analysis shows that tertiary CO_2 recovery is affected by the water saturation in the core after the secondary WF. Moreover, the fracture-matrix transport function during tertiary-CO_2 flooding is dominated by the diffusion rather than the convective flux or viscous forces.

The outcome of this work is an important step towards modeling the tertiary-CO_2 flooding in an actual fracture-chalk system. Proper modeling of imbibition and diffusion dominated processes in a chalk system at reservoir conditions has been accomplished.

Keywords

Fractured-chalk
Water flooding
Spontaneous imbibition
Tertiary-CO_2 flooding
Diffusion
Vaporization

1. Introduction

The potential of using CO_2 flooding as a promising technique in secondary or tertiary oil recovery attracts great attention during the last few decades. Many studies report the successful utilization of CO_2 as an efficient enhanced oil recovery (EOR) agent mainly in US oilfields. Mature oilfields in the west Texas have been an attractive target for CO_2-EOR projects. There are more than 100 active CO_2-EOR projects in the Permian Basin (Moritis, 2004; Manrique et al., 2007; Rogers and Grid, 2006).

Many field studies are conducted to evaluate the efficiency of CO_2 flooding under water-alternating-gas (WAG) injection in water flooded fractured reservoirs. Jensen et al. (2000) perform an EOR