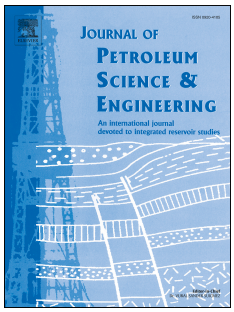
Accepted Manuscript



Tertiary-CO_2 flooding in a composite fractured-chalk reservoir

M. Ghasemi, W. Astutik, S. Alavian, C.H. Whitson, L. Sigalas, D. Olsen, V.S. Suicmez

PII: S0920-4105(17)30830-6

DOI: 10.1016/j.petrol.2017.10.054

Reference: PETROL 4377

To appear in: *Journal of Petroleum Science and Engineering*

Received Date: 16 June 2017

Revised Date: 13 September 2017

Accepted Date: 18 October 2017

Please cite this article as: Ghasemi, M., Astutik, W., Alavian, S., Whitson, C.H., Sigalas, L., Olsen, D., Suicmez, V.S., Tertiary-CO_2 flooding in a composite fractured-chalk reservoir, *Journal of Petroleum Science and Engineering* (2017), doi: 10.1016/j.petrol.2017.10.054.

Tertiary-CO_2 flooding in a composite fractured-chalk reservoir

M. Ghasemi, W. Astutik, Petrostreamz; S. Alavian, C.H. Whitson, Pera AS; L. Sigalas, D. Olsen, Geological Survey of Denmark and Greenland; V.S. Suicmez, Maersk Oil and Gas A/S

Abstract

This paper presents the oil recovery mechanism by tertiary-CO_2 flooding in a composite fractured chalk core. We perform two different core flooding experiments at reservoir conditions. We evaluate the efficiency of tertiary-CO_2 flooding in different conditions, taking into account the effect of capillary continuity, water composition, and the heterogeneity.

The composite core consists of six core plugs placed vertically in-line in the core holder with total length of 45 cm and average diameter of 3.74 cm. We use qualitative filter paper between each core plug to reserve the capillary continuity at reservoir conditions (258 bara and 110 ^{o}C). The "fracture" is represented by a centralized axial hole with a diameter of 0.6 cm. In all experiments, the composite fractured core is initially saturated with North Sea Chalk Field (NSCF) stock tank oil (STO) and synthetic connate water. Once the reservoir conditions are established, brine is injected from the bottom of the fracture and the oil is produced from the top. We stop water flooding (WF) after no more oil is being produced. CO_2 is then injected from the top of the fracture and the oil is produced from the bottom.

Experiments Exp-1C and Exp-2C utilize Sigerslev outcrop chalk cores. To account for the effect of initial water composition during WF, system is initially saturated with synthetic sea water with considerable amount of sulfate instead of formation water in Exp-1C. Whereas, we employ synthetic formation water with zero sulfate content in Exp-2C.

The results of experimental work are reproduced via validated compositional reservoir simulator with a tuned equation of state (EOS). We develop an automated history matching algorithm to match the experimental data of WF and CO_2 flooding (CF) periods.

We observe a major impact of the initial water composition that results in strong- to moderate-spontaneous imbibition during WF period. Moreover, both experiments and simulations show that the tertiary CO_2 recovery is significantly affected by the water saturation in the core after the secondary WF. We conduct a sensitivity analysis to study different CO_2 injection scenarios such as in a single block, in a composite core with capillary continuity, and in a composite core with horizontal fractures in between. The results show the oil recovery during tertiary-CO_2 flooding is barely affected by the degree of the capillary contacts between the chalk matrixes. Moreover, it is found that the mass transport during CF is mainly covered by diffusion rather than the convective flux or viscous forces.

We build a modeling framework that accounts for proper modeling of imbibition and diffusion dominated processes in a composite chalk system at reservoir conditions.

Keywords

Composite fractured-chalk
Water flooding
Spontaneous imbibition
Tertiary-CO_2 flooding
Diffusion
Capillary continuity