Simulation using CO₂ for IOR/EOR in the discovery C, Barents Sea, Norway

Pham V.T.H.1, Halland E. K.1, Tappel I. M.2, Gjeldvik I. T.1, Mujezinovic J.1, Riså F.1
1Norwegian Petroleum Directorate, Stavanger, Norway

Abstract

Based on geological and geophysical modeling, the segment model in the Fr. Formation is built and shows an area of nearly 0.15 km² with a small gas cap on top and oil-in-water conditions. In the C structure model, a segment model was cropped out and simulated with CO₂WAG injection. CO₂ is used as gas (water-alternating CO₂ gas). The CO₂WAG injection method was compared with other recovery methods like gas injection, water injection and WAG injection (gas is hydrocarbon gas). Simulations show promising results on the CO₂WAG method in early period compared to the other recovery methods. Lessons from this study show that when a reservoir is near critical temperature, it is very difficult to predict CO₂ behavior and oil/gas production volume when CO₂ can be in both gas and liquid phase.

1. Introduction

The C Structure is defined as a half-open basin structure situated in the northern boundary area of the Finnmark Platform. The Fr. Formation generally reflect deltaic depositional environment following a widespread Early Norian marine transgression in the Barents Sea region. Hydrocarbons have been proven in the Fr. Formation and the formation is identified as oil bearing. The reservoir sand-porosity is about 20-25% and permeability is between 10-100 md.

In the exploration well, the Fr. Formation was drilled at depth between 830-1200 m with an approximately thickness of 120 m. In the segment model, there are three wells, two production wells and one injection well. The same injection rate of water, gas or CO₂ (in the reservoir condition) was injected into the reservoir with 3 month-cycle Gas and Water alternative. In the gas injection scenario, the injection well was placed in order to inject gas in the gas cap.

2. The reservoir simulation model

Different oil and gas recovery methods have been used for this model. The same injection rate of water, gas or CO₂ in the reservoir condition is injected into the reservoir. In the model, there are three wells, two production wells and one injection well. In the gas injection scenario, the injection well was placed in order to inject gas in the gas cap.

In the C structure model, a segment model was cropped out and simulated with CO₂WAG injection. CO₂ is used as gas (water-alternating CO₂ gas). The CO₂WAG injection method was compared with other recovery methods like gas injection, water injection and WAG injection (gas is hydrocarbon gas).

3. Results

Simulations show promising results on the CO₂WAG method in early period in both CO₂WAG: 30°C and CO₂WAG: 80°C cases compared to the other recovery methods. It shows less cumulative oil volume in long-term in the case CO₂WAG: 30°C and very optimistic in the case 30°C. The explanation for this is in the Discussion part.

4. Discussion

The different of CO₂WAG cases are reservoir temperature, pore-oil CO₂WAG with temperature 30°C and it is lower than the critical temperature, CO₂ in fluid phase and consider as one component of oil. This means the total oil production volume consists of real oil and CO₂ liquid phase. That can be seen in the result of the other case with the temperature 33°C, that is higher than critical temperature. And therefor CO₂ could be gas phase and that is not included in the oil production profile. Lessons from this study show that when a reservoir is near critical temperature, it is very difficult to predict CO₂ behavior and oil/gas production volume when CO₂ can be in both gas and liquid phase. More simulation research should be done to get optimizing oil production volume and the effectiveness of mixing of CO₂ and gas when we have the mining available.

5. Summary

CO₂ injection is effective for increasing oil recovery, probably in short period after 5 years after injection in this model. The oil production volume results could be very high in the cases with reservoir temperature lower than critical temperature of CO₂, this is due to CO₂ is reproduced and included in total oil production volume.

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7. References