10th Biennial International Conference & Exposition

P 074

CO_2–EOR from Oil Reservoir Models of Turbidite Depositional Environment

*I. Akervoll *, P.E. Bergmo and M. Felix*

Summary

The current paper presents the results from reservoir simulations of water injection and tertiary CO_2 injection into turbidite oil reservoir models. The CO_2-EOR (enhanced oil recovery by CO_2) potentials from the models are calculated in fraction of original oil in place. Estimating the EOR potential in producing oil fields is an important input to decision making for large scale deployment of CO_2-EOR

Keywords: *Reservoir simulation, CO2 injection, Turbidites, Enhanced oil recovery*

Introduction

Turbidite deposits in the North Sea may be considered as candidates for CO_2-EOR. The proposed framework for the current reservoir modelling is to consider 'generic' sector models, representing relevant geological settings in the North Sea by populating the model with several different sets of geological properties.

The purpose of the study is to present the synthesis of conceptual model incremental recovery and the CO_2 storage potential from simulations of CO_2 injections and CO_2 WAG injections into conceptual reservoir models that are constructed to represent water flooded oil fields of typical turbidite deposits.

The target EOR is the residual oil left behind either as bypassed oil zones or as capillary trapped residual oil after water flooding leaving tertiary recovery methods like CO_2 injection as options to enhance the recovery (Akervoll and Bergmo, 2010).

Method of the study

The reservoir models have been constructed to represent turbidite depositional environment in the range from small fan systems (few km in each horizontal direction) to large systems (tens of km long). The bed thicknesses (amalgamated or not) range from tens of centimeters to a hundred meters. A facies model was generated with three grain sizes: mudstone (background), coarse sand and fine sand.

The reservoirs have been under water flooding for about 0.6 HCPV of the EOR target volume. The CO2-EOR potential is defined as the additional oil recovery in volumes or fraction of HCPV on top of water injection for the same number of HCPV or years of the CO2 injection scheme. A large set of reservoir simulations were performed on the deposit models to investigate parameter sensitivity to CO2-EOR. The analysis of the sensitivities has allowed identification of the operational parameter and static reservoir parameter which have the most and the least influence on oil recovery under different conditions.

The CO_2storage potential is extracted from the grid at the end of CO_2 injection and includes free and residual CO_2 saturation, CO_2 dissolved in mobile and initial water saturation as well as in residual oil saturation. The analysis of the sensitivities have allowed to identify which operational parameter and static reservoir parameter have the most and the less influence on oil recovery under different conditions. The spread of the EOR results expressed as fraction of HCPVof continuous CO_2 WAG injection beyond water flooding are presented. The EOR profiles are the average profile, maximum

Dept of Geophysics and Reservoir Technology, SINTEF Petroleum Research,S.P. Andersens vei 15b N-7465 Trondheim Norway,
Email: idar.akervoll@sintef.no

profile, minimum profile, average profile minus standard deviation of all profiles and average profile plus standard deviation of all profiles for all simulation cases.

Example

Conceptual reservoir models representing turbidite oil reservoirs have been defined and constructed based on average values from literature as described above. One model represents central parts of a submarine fan/turbidite system with good reservoir properties. A facies model was first generated with three facies, mud stone (background), coarse sand and fine sand. The facies model was stochastically generated with sand channel thickness between 20 and 50 meters. **Error! Reference source not found.** shows a generated facies model.

The geometry of the North Sea conceptual reservoir models, the grid, the depth and the well positions are shown in **Error! Reference source not found.**. The area extent of the model is 1450 m in length and 790 m in width. The thickness of the reservoir model is 46 ± 1.2 m. The reservoir model is penetrated by two wells, one injector (I1, water and gas) and one producer (P1). One well is located down-flank below the oil-water-contact (OWC), the other well at the crest or top of the model. The distance between the wells is 1000 m. Both wells can be used as injector or producer and can be connected to the grid either in the entire height of the well or in selected layers of the grid. The depth of the reservoir model extends from 2940 m to 3040 m in true vertical depth sub surface (TVDSS).

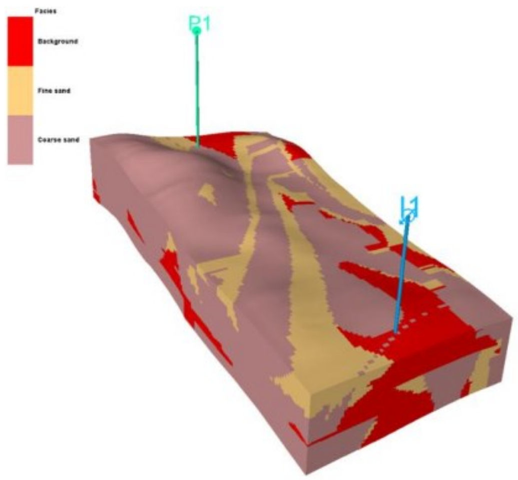

Figure 1: Facies model for the conceptual turbidite model.

Porosity modelling was guided by the facies model with a range between 4 and 28 %. The porosity within each facies is normal distributed. Figure 2 shows the porosity distribution in a model.

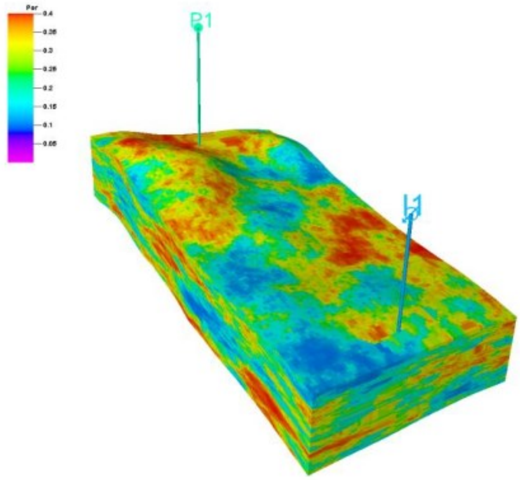

Figure 2: Effective porosity distribution in the turbidite North Sea conceptual model.

The conceptual fluid model is composed and tuned to reflect the HCPV weighted average value of this type oil reservoirs. The molecular weight and the mol fraction of the plus-fraction (heaviest components) are tuned and the gas-oil ratio is changed to account for density and viscosity variation of the oil as described elsewhere (Holt and Lindeberg, 2003).

The relative permeability functions are derived by use of Corey relative permeability correlations. The oil, water and gas relative permeability curves with hysteresis in nonwetting and wetting phases. Simulation runs have been performed using a commercial black oil simulator (Eclipse www.slb.com)) with hysteresis options and Todd-Longstaff miscibility options available in the software package.

Conclusions

For the present definition of conceptual EOR models of formation from deep North Sea basin representing central parts of a submarine fan/turbidite system with good reservoir properties, were selected as basis for the definition.

A substantial difference was recorded between the most and the least EOR efficient CO_2WAG injection cases for the turbidite deposit models. The performance of the medium EOR efficient case is less than 10 % of hydrocarbon pore volume and is as expected in the range between the most and least EOR efficient.

The oil end-point saturation values after water injection are the most sensitive parameters with respect to the EOR efficiency.

Acknowledgement

We acknowledge the ECCO–European Value Chain for CO_2 project for the financial support for this research work. ECCO is a European research project funded by the European Commission under the 7th framework programme for research (7FP) and by industial companies within power generation and oil and gas production
(http://www.sintef.no/Projectweb/ecco/).

References

Akervoll, I., Bergmo, P.E.: "CO2 EOR From Representative North Sea Oil Reservoirs", SPE139765, SPE International Conference on CO2 Capture, Storage, and Utilization Conf., New Orleans, LA, USA, 10 - 12 Nov. 2010.

Eclipse Reservoir Simulation Software v. 2009.2, www.slb.com

Holt, T. and Lindeberg, E., 2003: "A techno-economical model for large scale deposition of CO2 in oil reservoirs and aquifers", Report 54.5255.00/03/03 SINTEF Petroleum Research, 45 p., Restricted