Paper Number 38924
Title Mass Transfer in Fractured Reservoirs during Gas Injection: Experimental and Numerical Modeling
Authors Le Gallo, Y., Le Romancer, J.F., Bourbiaux, B., Fernandes, G., Institut Francais du Petrole
Source SPE Annual Technical Conference and Exhibition, 5-8 October, San Antonio, Texas

Abstract

The mass transfer processes occurring during near-miscible gas injection represent an important IOR potential. This study improves the physical and numerical modeling of mass transfers during gas injection in fractured reservoirs.

The objective of the experimental study was to obtain reference measurements under reservoir-representative conditions with well-characterized hydrocarbon mixtures. These experiments quantified oil swelling and vaporization and showed the influence of non vaporizable fraction.

The experiments were simulated with a compositional numerical model taking into account all the physical mechanisms involved such as capillary phenomena, diffusion and transfers at the matrix-fracture boundary. This exhaustive modeling methodology enables a thorough understanding of the three experiments considered: oil swelling, influence of non vaporizable fraction, influence of nitrogen injection.

Introduction

During the primary exploitation of fractured reservoirs most of the oil is produced from the fractures, the matrix remaining highly saturated with oil. Gas injection allows to recover substantial amount of the matrix oil by gravity drainage.

Nevertheless, in case of low permeability, small size matrix blocks with high gas-oil capillary pressure, the recovery efficiency of gravity drainage is often very low. Hence recovery due to mass transfer between gas in the fracture and gas/oil system in the matrix blocks must be taken into account to improve production forecast. Oil swelling due to gas dissolution in the oil phase and the vaporization of light oil fractions significantly improve oil recovery in such cases.

The purpose of this study is to evaluate the incremental oil recovery due to mass transfer phenomena in fractured reservoirs.

Espie et al have performed gas flood experiments on real fluids to evaluate oil recovery by vaporization. Experiments were conducted under reservoir conditions. They showed that C6+ recovery by vaporization was around 28% of the trapped oil remaining after equilibrium gas flood.

The problem of mass transfer between matrix blocks and fractures is studied through experiments with tangential flow at one end of the core.

Morel et al have performed diffusion tests with synthetic mixtures. They showed that nitrogen injection lead to liquid accumulation near the fracture. This effect was attributed to the interfacial tension gradient involved in the ternary fluid system (N_2,C_1,C_5). Because of this gradient, the capillary equilibrium is reached at a lower gas saturation near the fracture. Morel's experiments were simulated by Hua Hu et al with a model combining an analytical calculation in the fracture and a numerical one in the core and by Fayers et al to test a compositional simulator. These authors showed the importance of diffusion computations and variations of capillary pressure with interfacial tension due to compositional effects.

In a similar configuration, the effect of water saturation on mass transfer was examined by Le Romancer et al. Water saturation influences differently the recovery depending on the diffusing gas. With methane injection, the oil recovery falls off all the quicker as water saturation is higher. With nitrogen injection, capillary phenomena override water effects and oil recovery kinetics remains constant whatever the water saturation.

Wylie et al carried out mass transfer and gas flood experiments. They confirmed that the higher the water saturation the lower the recovery.

The effect of the diffusing gas was investigated by Le Romancer et al. They compared the effect of methane, nitrogen and carbon dioxide.