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Evaluation of Infill Drilling Opportunities in Lekhwair Field, Oman

Shekhar Jayanti, SPE, Anil Chopra, SPE, Ronald M. Giordano, SPE, Hua Yuan, SPE, and Hongguang Tie, SPE, PetroTel Inc. and Ali Suleimani, SPE, Ali Gheithy, SPE, and Clement Edwards, SPE, Petroleum Development Oman

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Abstract

This paper presents an evaluation of infill drilling opportunities in a mature waterflood. Different infill drilling configurations for increased oil recovery are compared using a ranking scheme. The field has been on production since 1976. The field has a complex development history, with periods of primary recovery, shut-in, 5-spot, inverted 9-spot, and direct line-drive waterflood. The field is currently undergoing a line-drive waterflood. The challenge is to find new infill drilling opportunities and determine optimal well spacing to maximize oil production.

Traditional infill drilling evaluations either use empirical techniques based on ad-hoc estimates of drainage areas or reservoir simulation of the field-level benefits of an infill drilling program. The former approach ignores the impact of reservoir heterogeneities while the latter approach makes it difficult to evaluate the contribution that each infill well makes to the field-level benefit. Our approach isolates the impact of each infill well and provides a fast and novel methodology to evaluate the incremental benefit while accounting for reservoir heterogeneity, well conditions, pattern configuration, injection rates, and voidage replacement ratio. This type of analysis helps optimize the number of wells to be drilled and at the same time leads to increased oil recovery through better waterflood management.

Streamline analysis was used to identify dead spots and regions of unswept oil in a part of the field. A novel waterflood management workflow was used to evaluate new infill well configuration strategies to increase oil recovery and better manage the waterflood. Optimization studies were also conducted to minimize the number of wells with the right combination of injectors and producers and obtain significant incremental benefits. Work is underway in the field to implement these recommendations and early results point to the success of this approach.

This paper presents a novel approach for evaluating the impact of infill drilling. The marginal utility of each infill well is calculated and then is used to optimize the number of wells and maximize oil recovery. The approach presented can be used to quantify the impact of infill drilling and increase oil rate and recovery in similar reservoirs.

Introduction

The field in North Oman has been on production since 1976. Fig 1. shows an areal view of the field. There are two producing formations in the field - Lower Shuaiba and Kharaib, which are separated by the Hawar shale. Fig 2. shows a cross-sectional view of the permeability in the field. The reservoirs are low permeability chalky limestones with permeabilities ranging from 1 to 20 md. The oil is light with 38 °API and has a viscosity of 0.8 cp. The field has a complex development history, with periods of primary recovery, shut-in, 5-spot, inverted 9-spot, and direct line-drive waterflood. The field is currently undergoing a line-drive waterflood. Primary depletion lasted until 1981. From 1981-1985, most of the wells were shut-in. A pilot waterflood using a five-spot pattern was undertaken from 1985 to 1991. The waterflood pattern was switched to an inverted nine-spot in 1991. The drilling pattern was changed to a direct line drive in 1996.

The focus of this study is a region of the field. The area of interest, Area C, has had more than 60% hydrocarbon pore volume of water injected and an oil recovery of 31%. This study looks at the impact of infill drilling in this area and presents optimized development strategies to maximize oil recovery.

Methodology

A dynamic model of Area C was history matched and simulations were run through the end of historical data, ending in May 2006. Prediction cases starting from June 2006 and going through January 2050 were simulated. The study focused on the impact of infill drilling of producers.

The base case prediction simulated the no further activity (NFA) field development scenario. The impact of infill drilling ten producers was modeled and compared against the base case. The performance of the infill wells was evaluated when they were drilled all together. The traditional approach would be to analyze the individual well performance and high-grade the well locations for optimal recovery. This does not take into account the performance of the existing base wells. The location and number of infill wells has an impact on the performance of the existing wells. In the approach presented