



SPE 110199

## A Method for Computation of Volumetric Sweeps for Individual Wells in a Waterflood

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This paper was prepared for presentation at the 2007 SPE Annual Technical Conference and Exhibition held in Anaheim, California, U.S.A., 11–14 November 2007.

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### Abstract

In this study, we have developed a procedure for estimation of volumetric floodable oil for producing wells in confined waterfloods from their performance data. For a given pattern, from the composite performance of all producers, we derive a set of field based relative permeability ratio vs. saturation using the procedure published by Ershaghi and Omoregie<sup>1</sup> (JPT Feb 1978). This requires a prior estimation of volumetric floodable oil in place for the entire block. Extending the same process to individual wells can generate a set of relative permeability ratios vs. the cumulative oil production. The conversion of cumulative production to saturation requires an estimation of volumetric floodable oil in place in the drainage areas of individual wells. An iterative procedure is used to estimate the floodable oil in place per individual producers when the reconstructed relative permeability set for a given well matches that derived for the entire flood pattern. Comparison of estimated oil within the drainage area, to that assigned from pattern geometries, generates drainage area invasion efficiency for each producer that is indicative of effective volumetric sweeps.

### INTRODUCTION

There are several causes when producing wells in classical patterns do not behave similarly. This is in part related to flow unit heterogeneities associated with the depositional setting within the pattern and in part may be because of non uniform distribution of hydrocarbon saturation. Performance plots on individual producing wells in a waterflood often show significant variations in cumulative produced oil at a given water oil ratio. Among the various causes, including lateral and vertical reservoir heterogeneities, the available and changing floodable hydrocarbon volume within the drainage area of

producers can have a substantial impact on the observed performance. Estimation of floodable hydrocarbon in place within a well's drainage area from performance data can further help in recovery forecasting via analytical or numerical methods.

For the purpose of this study, we focus on the composite floodable oil in place and assume no interference from near wellbore effects. A fundamental assumption made here is that the relative permeability ratio vs. saturation of the producing formation is similar at all locations within the bulk of the producing interval.

Procedurally then one needs a base set of relative permeability curves for the entire waterflood zone. A method presented by Ershaghi and Omoregie provides such an opportunity. This method has been used in other field studies<sup>2-4</sup>. In this method, the actual performance data of the waterflood area is used to obtain a set of field based relative permeability ratios.

The goal here is to examine the performance data on the individual wells and by making the fundamental assumption mentioned above, obtain an estimation of floodable hydrocarbon in place for individual producers in the confined waterflood area and monitor changes indicating oil drainage or resaturation.

In this study, we develop the work process and calibrate it with simulated data. We then examine the application of the suggested process for an actual waterflood. We have successfully tested the method for various pattern geometries using 2-D modeling.

The proposed method is introducing a novel analytical tool in waterflood monitoring and management.

### Methodology

The Ershaghi et al's X-plot technique is a convenient way to transform waterflood performance data and to estimate a set of field relative permeability ratios. The major assumption of the X-plot technique is that the main portion of the relative permeability ratio vs.  $S_w$  is a straight line on a semi log scale and can be expressed as: