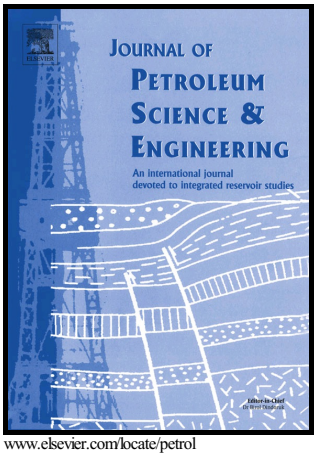

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Determining Well-to-Well Connectivity in Tight Reservoirs

Mammad Mirzayev[1*], Naimeh Riazi[2], David Cronkwright[2], Jerry L. Jensen[1], Per K. Pedersen[2]

[1]Department of Chemical and Petroleum Engineering, University of Calgary
[2]Department of Geoscience

[*]Corresponding author. mtt013@gmail.com

Abstract

Drilling and fracture stimulating horizontal wells in low permeability fields, such as tight oil reservoirs, is a common practice. Estimating the connectivity between these wells (IWC) is important for the design and management of a field, especially when waterflood recovery is applied. For example, IWC affects the determination of fracture conductivity and length and can help identify favorable locations for infill drilling and optimize injection rates. In this paper, we show how an alternative method, developed for and successfully applied in conventional reservoirs to determine IWC, can be modified to estimate tight formation IWC using solely production- and injection-rate fluctuations. The model is based on the Capacitance Model, or CM, and is modified to include a pseudo well (CM-PW). The CM-PW is tested with various heterogeneous simulation cases and field data. The CM-PW can identify inter-well heterogeneities. The model accuracy is based on the match to production data and, for all simulation cases, the model accuracy is good with $R^2 \geq 0.83$. The field application, from a tight oil waterflood in the Bakken Formation, shows that the CM-PW results are consistent with tracer test results and field reports showing fracture hits between wells. The CM-PW evaluations also correlate well with the seismically-derived acoustic impedance. Integrating the connectivity analysis with tracer tests, seismic, and the geology enabled us to identify reasons for the connectivity observed, assessing whether injected fluid flows through the reservoir matrix or fractures between injector-producer pairs.

Keywords: Connection type; tracer test; hydraulic fracturing; well-towell connectivity; seismic attributes; percolation.

1. Introduction

In conventional reservoirs, the capacitance model (CM or CRM in some texts) has been successful in evaluating interwell connectivities (IWCs), even prior to water breakthrough (Izgec and Kabir, 2010). Early applications avoided analyzing flow rates during time periods which included well interventions or conversions to honor the CM assumptions. Since then, modifications have emerged to tolerate changing well operating conditions. Kaviani et al. (2012) proposed the segmented CM for the absence of measured BHPs and the compensated CM for cases with producer shut-in periods.

Since the wells in tight oil reservoirs may be treated (e.g., acid squeezing, fracturing) frequently, choosing an appropriate time window to perform connectivity analysis becomes difficult. Even in a small area with only a few wells, selecting periods can be problematic, making the CM impractical to run for a large unconventional field. Mirzayev and Jensen (2016) modified the CM to be compatible for evaluating IWC in such situations by defining an area (spatial window), where a limited number of wells exist and they may have interactions with wells outside the window (Kaviani, 2009). When spatial windowing is done (Fig. ***1***), the effect of the injection rate change on the producer of interest becomes even visually interpretable.