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Improved Data Characterization and Integration for better Hydraulic Fracturing Design Prediction

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Introduction

Recent advances in reservoir data measurements and analysis (microseismic, tomographic images, pressure decline analyses, PLTs…) have provided the industry with a procedure to estimate a posteriori the efficiency of stimulation jobs, leading to the determination of Stimulated Reservoir Volumes. These results, confirming the important impact of heterogeneities on field recovery efficiency (mineralogy, natural fractures, petrophysical and geomechanical properties), are then used to develop the field (Cipolla et al 2000, Fisher et al 2002, Walser & Ranjan 2016, Shojaei & Lipp 2016). Yet, for a lack of data or computational limitations, the modeling process often homogenizes or pseudoizes fracture network complexity. This enables some data history match, even if geometry input does not agree with observations, but it is not always pertinent for predictions (Vincent 2009, Mark 2015) and causes problems especially for predictions. At the same time the major challenges operators are facing with unconventional resources, is controlling the stimulation design which provides commercial production from a well predicted stimulated reservoir volume. This also spotlights questions for reservoir engineering: What useful data leads to efficient control and forecasts? How to represent the tight reservoir in a practical model suitable for predictions? How field operations can be optimized? Answering this requests to develop a predictive approach which explains the impact of key drivers on stimulation and production at various scales.

Theory and/or Method

To select the best candidate for stimulation, the design engineer must consider many variables at a given time. They can be sorted into two groups along the overall field development: data that can be “controlled” by the engineer and data that could be measured or estimated, but cannot be controlled. Each oil and gas prospective zone being different, with multi-scale complexity (rock properties, fracture attributes, long transients…), the required hydraulic fracturing design and field development need to be tailored to the particular conditions of the formation, integrating the second group data type. Since tight reservoirs production requires increasing exchanges with the formation often through fractured paths created by hydraulic fracturing, stimulations are particularly sensitive for the presence of natural fractures (McClure 2013, Vassilellis & Elrafie 2016). The hydraulic pressure increase may indeed open the natural fracture system as well as induce hydraulic fractures, resulting in additional complex fractures geometries potentially leading to unexpected productions.

Thus characterization of unconventional reservoirs implies the conciliation of several scales, integrating potentially a large fracture information database. This puts demand on the more general subject of modeling (Lecampion et al 2015, Shahid et al 2016). Historically several approaches have been attempted and validated, yet answering only partially to the all problem exposed above. Recently, due to efficient meshing techniques (Khvoenkova & Delorme 2011), a new model (Delorme et al 2016, Ricois et al 2016) is able to conciliate several scales during the (stimulation – multiphase production) cycle. Several multi-staged wells can be treated at the same time within a common characterization framework able to describe the involved fracture system (natural and stimulated) at a finer scale. Fracture geometries can be simple or more complex, what enables model comparison and several reservoir type studies.

Examples

In this paper an hydraulic fracturing treatment conducted in the tight Wolfcamp reservoir (Khvoenkova et al 2015) is used to illustrate and discuss limitations and advantages of our predictive methodology. Using the original dataset (logs, seismic etc…) and varying uncertain parameters, the first stage is history matched for both microseismic and BHP. Calibrated parameters are further used in other stages in order to check predictability until reaching the desired prediction. For that, a practical predictability index is developed, synthesizing the complexity of our problem and helping decision on whether to acquire more data or to extend our description to a larger scale (2 or 3 wells).

Conclusions

This innovative integrating unconventional reservoir simulation methodology gives some insights on hydraulic fracturing key questions raised above. The efficient coupling between geological characterization and geomechanical concepts allows simulation on up to half-a million fractures, including the porous tight matrix in tractable CPU times. The guidance provided here will help to better define economical or technical indicators. This methodology is intended to equally apply to tight reservoir supposed to be hydraulically stimulated.

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