Geomechanical modelling using poro-elasticity to prevent frac hits and well interferences

A., Ouenes[1,2*], A. Bachir[1,2], A. Khodabakhshnejad[1] and Y. Aimene[1,2], present a practical application of production and pressure depletion forecast in unconventional wells using an asymmetric analytical tri-linear model and fast marching method.

Introduction

Modelling unconventional reservoirs requires a continuum multi-scale approach to represent the dominant physics occurring at each scale (Figure 1). In the most common far field studies (thousands of feet around the wellbore), geophysics used in conjunction with processes such as facies constrained extended seismic elastic inversion (Kiche et al., 2016) provide dynamic geomechanical properties throughout the entire reservoir volume – properties, which are critical to the optimal selection of landing zones and completions of unconventional wells. It is also in the far field that the combination of geomechanical properties with continuous natural fracture models (Jenkins et al., 2009) are used as input in a robust reservoir geomechanics workflow (Aimene and Ouenes, 2015) that is able to simulate the interaction between the regional stresses and the three major sources of stress gradients affecting hydraulic fracturing: variable geomechanical properties, geologic discontinuities, and pore pressure variability. The resultant locally-varying differential stress distribution provides the initial reservoir stress conditions before fracking and the correct input for the estimation of strain during and after hydraulic fracturing, which should be validated with a predicted microseismicity (Aimene and Ouenes, 2015). This strain provides coupling between the far and mid field studies and creates the unique opportunity to constrain the mid-field frac design (Paryani et al., 2016) and reduce the uncertainties of multiple frack design parameters by constraining lateral stress gradients and imposing the asymmetric frac lengths that the earth will allow. The behaviour of the mid-field hydraulic fracturing is also affected by multiple near field effects such as type of completion (Peterson et al., 2017) and its effects on the near wellbore geomechanics. The near field effects could be estimated at any well using surface drilling data (Jacques et al., 2017) which could provide the necessary information required in the mid and far fields in the inverse design and validation process in situations where there is lack of data.

This multi-scale continuum workflow implemented in a single software and field validated at each scale, stands in sharp contrast with other convoluted workflows where multiple software using different computational methods are applied to different types of grids (Finite elements, discrete fracture networks, structured and unstructured grids). In the late 1990s, using an unstructured grid to capture complex flow patterns in fractured reservoirs and around wells was a necessity imposed by computer hardware (Heinemann et al., 1998). Today's computer power allows trillion gridblock reservoir simulation (World Oil, 2016) and seismic bin sizes less than 10 m. This new computation environment means that modelling an unconventional reservoir using a single high definition structured grid with very small cell size in the 1-5m range is possible. The seamless integration of disciplines using one structured grid was illustrated with the use of 3G workflows to improve frac design (Ouenes et al., 2016).

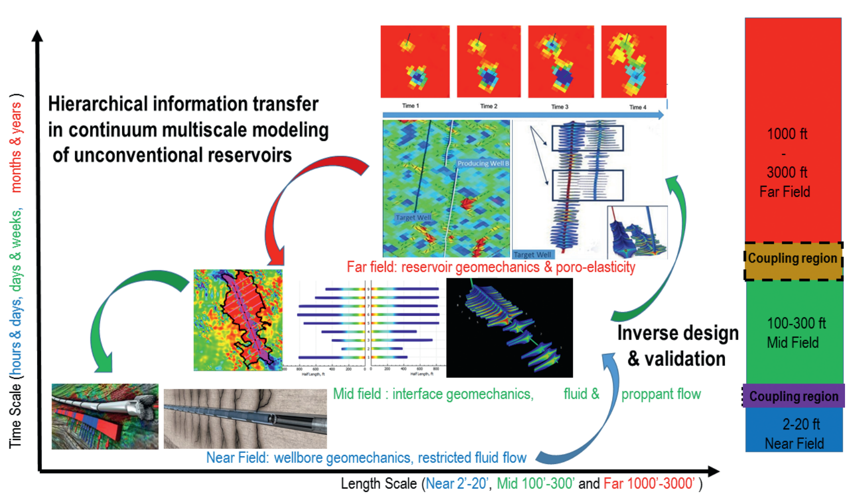

Figure 1 Modelling of unconventional reservoirs approached as a continuum multi-scale problem where different tools are used to capture the dominant physics occurring in the far, mid and near fields of the wellbore.

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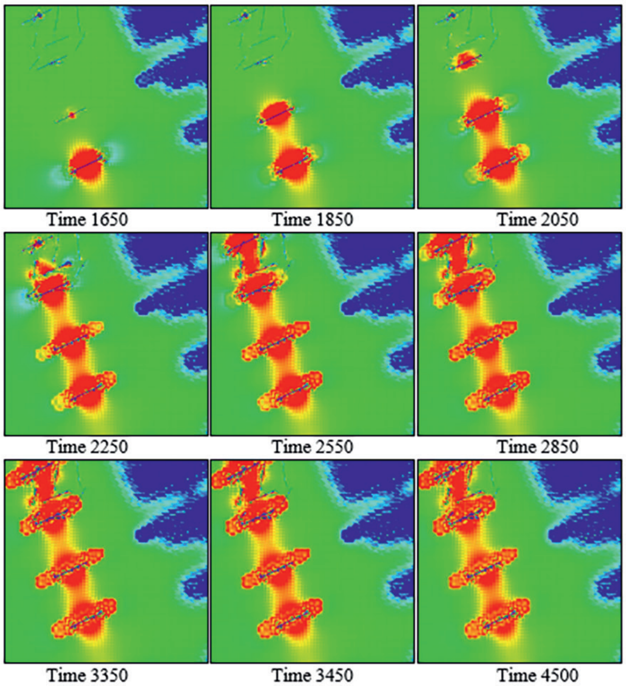

Figure 9 Evolution of the pore pressure during the sequential fracking of stages 3 to 6 when the child well is 1300 ft away from the parent well (animation at https://www.youtube.com/watch?v=fu2PncSjSVk)

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