

EGU2020-19988

<https://doi.org/10.5194/egusphere-egu2020-19988>

EGU General Assembly 2020

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Multi-Scale Simulation of Hydraulic Fracturing and Production: Testing with Comprehensive Data from the Hydraulic Fracturing Test Site in the Permian Basin

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The Hydraulic Fracturing Test Site (HFTS) project, fielded a few years ago within the Wolfcamp Formation in the Permian Basin in the United States, provides an excellent opportunity to further develop our understanding of the geomechanical response to hydraulic stimulation and associated production in shale lithologies. In addition to a full set of geophysical and tracer observations, the project obtained core samples from wells drilled through the stimulated region, characterizing the propagation of fractures, reactivation of pre-existing natural fractures, and placement of proppant. In addition to providing an overview of the available field data from the field test, we describe here a multi-scale modeling effort to investigate the hydrologic, mechanical and geochemical response of the Wolfcamp Formation to stimulation and production. The ultimate outcome of this project is the application and validation of a new framework for microscopic to reservoir scale simulations, built upon a fusion of existing high performance simulation capabilities.

The modeling occurs across two spatial domains – the “reservoir scale”, which encompasses the intra- and inter-well regions, and the “inter-fracture scale”, which is the region between stimulated fractures. Physics-based simulations of the fracture network evolution upon stimulation at the reservoir scale using the simulator GEOS provide input for reservoir-scale production simulations conducted with the TOUGH family of codes. At the inter-fracture scale, the fluid dynamics and reactive transport Chombo-Crunch code is used simulate the micro-scale pore-resolved physical processes occurring at the fracture and rock interfaces upon stimulation and production, tested against laboratory studies of proppant transport and pore-scale reactions. Micro-scale modeling and imaging provides upscaled flow and transport parameters for larger-scale reservoir modeling and production optimization.