NEXT GENERATION RESERVOIR ENGINEERING

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Our mission is to advance knowledge about energy in transition with the aim to aid the industry in the imminent energy transformation. To this end we use an approach based on developing a fundamental physics based understanding of the chemical, mechanical, thermal and hydrological processes and their interactions that operate over long time scales to form and characterise the porosity/fracture networks in conventional and unconventional oil and gas reservoirs. We apply that understanding to engineer that structure for the purpose of energy extraction and resource discovery. The interdisciplinary approach links geoscience, engineering and computational science disciplines with the result of providing a step change in exploration and exploitation technologies with significant reduction in onshore gas development costs without compromising OHSE or environmental protection and assurance.

Numerical simulation has played a pivotal role in the dynamic reservoir modelling and for testing competing hypotheses in complex, typically data-poor environments. Though our ability to rigorously describe key processes in petroleum reservoirs is still imperfect (in particular Unconventional Plays), there have been substantial advances over the past several decades. These advances owe mainly to the steady growth of computational power and the concomitant development of numerical models that have gradually minimized various simplifying assumptions. They include incorporation of more accurate description of the fluid chemistry and its multiphase evolution and fluid flow rock interaction, an increased ability to represent geometric complexity and heterogeneity, and faster and more accurate computational schemes. In collaboration with international partners we have prototyped a Multiphysics, Multiscale Simulator based on the Open Source **M**assively **O**bject **O**riented **S**imulation **E**nvironment (MOOSE), originally designed for running synchronous Multiphysics calculations for a Nuclear Power Plant. The Multi App framework allows coupling processes at grain level through to the fission in the reactor core, including the large-scale fluid flow in the pipe network of the heat exchangers of the power plant.

In this presentation, we will show the first results that allow incorporation of important processes in Unconventional Plays. Surprisingly, diagenetic processes such as the smectite-illite transition are found to create natural fractures under tectonic load that form the permeable reservoirs in Shale Gas/Oil Reservoirs. Results indicate that the fractures triggered by natural fluid release reaction on geological time scales are supported by a critical fluid pressure that must not be crossed to avoid sudden loss of the reservoir. Upon crossing this threshold reservoir damage can be substantial. No amount of proppant or other engineering interaction can rescue the reservoir on a human time-scale. Our novel framework allows to link the long-time scale geological processes with the design of an injection-extraction protocol to maintain critical fluid pressure. We are also able to incorporate micro-structural changes and fluid-solid interaction at grain scale. The latter has only been benchmarked for conventional carbonate plays, but the Multiscale results are encouraging for the entire spectrum of conventional and unconventional traps/source rocks. Our theoretical framework and the forward simulator is specifically designed to interface with geophysical inversion techniques for multi-scale geophysical data. Completing this data-assimilation step in the future will define Next Generation Reservoir Engineering.