Massively Parallel Modelling of Coupled Thermal-Hydro-Mechanical Processes During In-situ Oil Shale Retorting

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High fidelity simulation of coupled thermal-hydro-mechanical (THM) processes is an enabling technology for the reliable predictions of field scale *in situ* oil shale retorting. Systems of coupled, nonlinear partial differential equations (PDEs) often arise in describing fluid flow, heat transport and deformation of oil shale rock. Traditionally, these systems of PDEs are solved using operator splitting, either by decoupling the problems and solving the resulting modified equations separately, or by coupling different codes via input files. However, such operator splitting approaches often converge very slowly for tightly coupled systems if they converge at all. In this paper, we present a massively parallel modelling approach to solve those coupled PDEs in a fully-coupled and implicit manner by applying an existing parallel software framework developed at Idaho National Laboratory (INL). One novel aspect of our approach is its integration into a fully implicit solution methodology based on the Jacobian-free Newton-Krylov (JFNK) method. JFNK provides a robust and efficient means of providing an accurate solution of coupled systems of partial differential equations across multiple scales. Another novel aspect of our approach is adaptive mesh refinement (AMR) in areas with large pressure and temperature gradients or in places with stress concentration. Laboratory-measured permeability and porosity as a function of temperature will be used as model input. Simulations of rock deformation and fracturing associated with oil shale retorting under various in-situ stress and heating conditions will be presented and discussed. Thermally-induced stress and fluid over-pressurization and their effects on existing fractures and faulted (or weakened) zones will also be simulated using the developed modelling approach.