Numerical modeling of in situ heating of oil shale

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To accurately model in situ techniques involving the heating of oil shale, the complex interplay between thermal, flow, mechanical, and chemical (TFMC) processes needs to be properly accounted. The evolution of flow properties is strongly dependent on the mechanical behaviour of oil shale. Additionally, thermal, mechanical, and chemical properties of oil shales depend on temperature and are expected to evolve during the conversion process. No contemporary commercially available simulator is capable of adequately mimicking the entire in situ heating process. ExxonMobil is collaborating with Los Alamos National Laboratory (LANL) to enhance the capabilities of LANL's existing fluid flow geomechanical simulator finite-element-heat-mass to adequately model processes with strongly coupled flow-mechanical coupling, specifically, in situ oil shale heating processes. Several key capabilities, including temperature dependence of rock properties, elasto-plastic deformation of oil shale, conversion of kerogen into oil and gas, multiphase flow of oil and gas, and enhancement of porosity and permeability resulting from stress changes, were added to the simulator. For flow-mechanics coupling, the simulator employs an explicit formulation as well as a fully implicit formulation that is expected to adequately describe steep changes in porosity and permeability due to mechanical deformation at a reasonable computational cost. The presentation will give an overview of the theoretical approach used for implementing the fully implicit flow mechanics coupling. A simple test problem, involving strong flow-mechanical coupling, will be used to compare results of explicitly and implicitly coupled formulations. Other test problems will be presented to illustrate the utility of other capabilities of the simulator and to demonstrate why those features are important to model in situ oil shale heating processes.