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A Coupled Multiphysics Approach for Simulating Induced Seismicity, Ground Acceleration and Structural Damage

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Numerical modeling has played an important role in understanding the behavior of coupled subsurface thermal-hydro-mechanical (THM) processes associated with a number of energy and environmental applications since as early as the 1970s. While the ability to rigorously describe all key tightly coupled controlling physics still remains a challenge, there have been significant advances in recent decades. These advances are related primarily to the exponential growth of computational power, the development of more accurate equations of state, improvements in the ability to represent heterogeneity and reservoir geometry, and more robust nonlinear solution schemes.

The work described in this paper documents the development and linkage of several fully-coupled and fully-implicit modeling tools. These tools simulate: (1) the dynamics of fluid flow, heat transport, and quasi-static rock mechanics; (2) seismic wave propagation from the sources of energy release through heterogeneous material; and (3) the soil-structural damage resulting from ground acceleration. These tools are developed in Idaho National Laboratory's parallel Multiphysics Object Oriented Simulation Environment, and are integrated together using a global implicit approach.

The governing equations are presented, the numerical approach for simultaneously solving and coupling the three coupling physics tools is discussed, and the data input and output methodology is outlined. An example is presented to demonstrate the capabilities of the coupled multiphysics approach. The example involves simulating a system conceptually similar to the geothermal development in Basel Switzerland, and the resultant induced seismicity, ground motion and structural damage is predicted.