Rapid analytical assessment of the mechanical perturbations induced by non-isothermal injection into a subsurface formation.

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Fluid injection into geological formations is required for several engineering operations, e.g. geothermal energy production, hydrocarbon production and storage, CO_2 storage, wastewater disposal, etc. Non-isothermal fluid injection causes alterations of the pressure and temperature fields, which affect the mechanical stability of the reservoir. This coupled thermo-hydro-mechanical behavior has become a matter of special interest because of public concern about induced seismicity.

The response is complex and its evaluation often requires numerical modeling. Nevertheless, analytical solutions are useful in improving our understanding of interactions, identifying the controlling parameters, testing codes and in providing a rapid assessment of the system response to an alteration.

We present an easy-to-use solution to the transient advection-conduction heat transfer problem for parallel and radial flow. The solution is then applied to derive analytical expressions for hydraulic and thermal driven displacements and stresses. The validity is verified by comparison with numerical simulations and yields fairly accurate results. The solution is then used to illustrate some features of the poroelastic and thermoelastic response and, in particular, the sensitivity to the external mechanical constraints and to the reservoir dimension.