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Upscaling of coupled geomechanics, flow, and heat, in a poroelastic medium in the quasi-static situation

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Motivated by geothermal energy storage in the subsurface, we undertake a formal derivation of a linear poro-thermo-elastic system within the quasi-static framework. This derivation is based upon the well known derivation of the quasi-static poroelastic equations (also known as the Biot consolidation model) from the micro structure, except that we now include energy conservation equations in the micro-scale model. These are coupled to the fluid/structure model by using linear thermo-elasticity for the solid structure instead of the usual linear elasticity. The resulting upscaled system is similar to the linear poro-elastic equations, but with an added conservation of energy equation, fully coupled to the momentum and mass conservation equations. We start at the pore scale, and apply the technique of homogenization to derive the upscaled model in the case of periodically distributed pores. Assuming the homogenization ansatz holds true, we obtain a fully coupled system of equations on the macro-scale accounting for the effects of geomechanics, heat transfer, and fluid flow within a fully saturated porous material.

References

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