Analysis of poro-visco-elastic solids at finite strains

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Poro-visco-elastic solids are materials in which a species diffuses and contributes to their deformation. Taking the Biot model as starting point, we discuss the modelling of (large) deformations and diffusion processes in a physically consistent way, and show that under certain assumptions weak solutions exist.

To model poro-visco-elastic materials, a free energy functional and dissipation potential are introduced. This energy functional has contributions both from the deformation gradient, i.e., an elastic contribution, and from a mixing term, which couples the deformation gradient and the concentration of the species. The dissipation potential features contributions for the viscous evolution and the diffusion process. In particular, since the focus is on finite-strain elasticity, the diffusion equation has to be pulled back to the reference configuration. As the pulled-back mobility tensor depends nonlinearly on the deformation gradient, and the viscous stresses are frame-indifferent, it is analytically necessary to include the hyperstress as a higher-order regularization, which makes this a second order non-simple material.

Another important property of the investigated model is that it allows for degenerate mobilities, which are more physically relevant; however, this greatly complicates the analysis, and requires an additional regularization step. This is in contrast to prior work, where only non-degenerate mobilities were considered. Still, under certain assumptions on the constitutive laws and the data, the existence of weak solutions to the coupled system is shown using variational methods.

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