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Numerical identification of a viscoelastic substitute model for heterogeneous poroelastic media by a reduced order homogenization approach

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Abstract

The paper deals with the computational homogenization of pressure diffusion processes in a poroelastic medium. The underlying physical phenomena are of interest for the interpretation of seismic data with applications in hydrocarbon production and geothermal energy. Pressure diffusion is assumed to take place on a length scale much smaller than the observer scale. Thus, the macroscopic observer is not able to measure the properties of the poroelastic medium directly but notices an intrinsic viscous attenuation. Under these circumstances, the macro-scale can be interpreted as a single-phase solid with (apparent) viscoelastic properties. In this paper, we establish a numerical upscaling procedure based on a volume averaging concept. This enables us to identify the material properties of the viscoelastic substitute model in a numerically efficient manner. For this purpose, the poroelastic medium on the small scale is modeled in terms of the momentum balance of the biphasic mixture and a coupled diffusion equation. We approximate the poroelastic pressure field on the small scale by a linear combination of pressure modes forming a reduced orthogonal basis and being identified by a Proper Orthogonal Decomposition (POD) technique. From the superposition principle, the evaluation of the poroelastic continuity equation results in a proper identification of the evolution equations defining the apparent

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