Biot/JKD's model : simulation of the propagation of poroelastic transient waves

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Abstract. We are interested in the propagation of poroelastic waves described by the Biot's model in high-frequency range, in time-domain where most of the existing methods have been developed in low-frequency range. The aim of the present study is to derive some numerical methods in all the domain of validity of the Biot's model. In high-frequency range, the effects of the viscous boundary layer inside the pores must be taken in account. We use the model of dynamic permeability of Johnson-Koplik-Dashen (JKD). So some coefficients of the Biot/JKD's model are proportional to the square root of the frequency. In the time-domain, the evolution equations are written in the form of an hyperbolic system with fractional derivatives, which generalize the notion of classical derivatives. It can be written with a convolution integral in time whose singular kernel is slowly decreasing and induced temporal memory.

To calculate these fractional derivatives, two strategies exist. The first one consists in directly calculating the involved convolution integral. However it requires to store the past of the solution, which is too penalizing in term of computational memory. The second one, which we implement, is based on a diffusive representation of the convolution kernel. It is replaced by a finite number of memory variables that satisfy ordinary local-in-time first order differential equations. To represent accurately the convolution integral, we choose an adapted quadrature rule and we obtained the convergence to the Biot/JKD's model.

The mathematical properties of the algorithm are analysed : consistency error, stability, optimization of the number of memory variables. Numerical solutions are compared to analytical ones, for some physical parameters representative of real media. The present algorithm makes numerical simulation of propagation through complex porous media accessible.

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