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Acoustical properties of dry and saturated porous media

P.M. Adler (1), I. Malinouskaya (1), V.V. Mourzenko (2), and J.F. Thovert (2)
(1) UPMC-Sisyphe, Paris, France(pierre.adler@upmc.fr), (2) LCD/ENSMA? Futuroscope, France

Our objective is to determine the macroscopic acoustical properties of porous media (either dry or saturated by an interstitial fluid) and to relate them to the mechanical and hydromechanical characteristics of the medium and its components. Wave propagation in a dry elastic material is governed by the elastodynamic equation. For a dry medium, the stress is zero on the pore surface.

The medium is supposed to be spatially periodic and composed of identical cells. When the wave length lambda is very large when compared to the scale l of the heterogeneities, the medium behaves in a first approximation as an equivalent homogeneous material. All the fields can expanded as series of the small parameter eta= l/2 pi lambda, in terms of two space variables associated to the scales lambda et l, respectively.
This expansion is introduced into the elastodynamic equation with appropriate boundary
conditions. A series of non homogeneous partial differential equations are found for the successive orders in eta. The predominant order corresponds to the equivalent homogeneous material. The first order equation provides the polarization correction, the second one the celerity dispersion and the third one the attenuation.

These equations are discretized by a finite volume formulation in a tetrahedral mesh which is either structured or not. The resulting linear system is solved by a conjugate gradient method. Each elementary volume may have specific properties.

Wave propagation in a saturated medium is more complex since it is influenced by the solid and liquid phases. When a periodic oscillation is imposed, the solid displacements are governed by the elastodynamic and the Stokes equations coupled by boundary conditions at the interface. The solutions to these equations yield the macroscopic characteristics of the medium.
The first equation yields two independent problems in the solid, one identical to dry media and one corresponding to a medium submitted to an interstitial macroscopic pressure. The second equation yields the dynamic permeability which is a complex function of frequency.

Various media have been addressed. Model media may be random packings of spheres
which can be partially consolidated by calcite, unimodal or bimodal reconstructed media. Real three dimensional samples made of several minerals were also obtained by computed microtomography.

All the results relative to these media will be presented and discussed.