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ACOUSTIC WAVE IN POROUS MEDIA

Numerical study of wave propagation in porous media with one or many mineral components. Applications to real Fontainebleau and STATOIL samples.

The purpose of this Ph.D. thesis is to study acoustic waves in porous media. The homogenization theory (*Boutin and Auriault*, 1990; *Malinouskaya*, 2007; *Li*, 2010) is used together with the lattice models such as LBM, LSM, LSM2S, LBM-LSM, LBM-LSM2S in order to determine the macroscopic properties, the acoustic velocities, the attenuation effects in Fontainebleau samples with two components (pore and quartz) and in STATOIL samples with three components (pore, quartz and clay).

Three problems are studied numerically in this work. The first problem is devoted to characterizations of samples; this is done with the determination of the porosity and of the correlation functions with the corresponding Fourier components (*Adler*, 1992; *Nguyen*, 2013). The second one addresses wave propagation in dry samples; the velocities are derived from the effective stiffness tensor $\boldsymbol{C}^{(eff)}$ which can be calculated by LSM (*Pazdniakou*, 2012) or LSM2S. The third one corresponds to samples saturated by incompressible or compressible fluids; the velocities can be obtained from the Christoffel equation after determining $\boldsymbol{C}^{(eff)}$, the dynamic permeability $\boldsymbol{K}$ and the reactions to fluid pressure $\boldsymbol{\alpha}$ and β.

For Fontainebleau samples, the calculations are performed with basic existing models such as LSM, LBM, LBM-LSM. These basic models are extended to solids with multiple components; they are validated by comparisons with others (*Nemat-Nasser and Iwakuma*, 1982; *Torquato*, 1998, 2000; *Cohen*, 2004).

The velocities, the effective bulk and shear modulus of all the dry samples as well as the velocities and the attenuation effected in saturated samples are determined. These results are in good agreement compared with existing models and results, such as the IOS model of *Arns* (1996), the empirical models of *Nur et al.* (1991), *Krief* (1990) and with Gassmann's model.

The numerical results are slightly larger than the experimental data of *Han* (1986) and *Gomez et al.* (2010); the origin of this small discrepancy has been tentatively analysed, but its cause has not been unambiguously identified.

Keywords: porous media, lattice models, compressible fluids, lattice Boltzmann model, parallel programs.