Course: Numerical Simulation in Applied Geophysics.

From the Mesoscale to the Macroscale

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Outline of Course Contents

Seismic wave propagation is a common technique used in hydrocarbon exploration geophysics, mining and reservoir characterization and production.

Local variations in the fluid and solid matrix properties, fine layering, fractures and craks at the mesoscale (on the order of centimeters) are common in the earth's crust and induce attenuation, dispersion and anisotropy of the seismic waves observed at the macroscale.

These effects are caused by equilibration of wave-induced fluid pressure gradients via a slow-wave diffusion process. Due to the extremely fine meshes needed to properly represent these type of mesoscopic-scale heterogeneities, numerical simulations are very expensive or even not feasible.

The course will present numerical upscaling procedures employing **Biot's theory** to determine the complex and frequency dependent stiffness at the macroscale of an equivalent viscoelastic medium including the mesoscopic-scale effects.

To determine the complex stiffness coefficients of the equivalent medium, we will describe a set of boundary value problems (BVP's) Biot's equations of poroelasticity in the frequency-domain solved using the finite-element method (FEM).

The BVP's represent harmonic tests at a finite number of frequencies on a representative sample of the fluid-saturated porous material, in the context of numerical rock physics.

Numerical rock physics offer an alternative to laboratory measurements, since numerical experiments are inexpensive and informative since the physical process of wave propagation can be inspected during the experiment.

Moreover, they are repeatable, essentially free from experimental errors, and may easily be run using alternative models of the rock and fluid properties.

Applications to characterize the seismic response of fractured hydrocarbon reservoirs and CO_2 sequestration will be discussed among other examples of application of the technique.

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