Wave propagation in soil-water mixtures at high pressure

M.Sc. Thesis Project

CTW- Multi Scale Mechanics (MSM)

Goal

Understanding the dependence of elastic properties on pore pressure in rock-fluid mixtures by means of hybrid numerical methods.

Background

Nowadays society is constantly involved in developing new energy systems along with the optimization of the already existing precesses. In the field of underground oil and gas exploration steps forward can be done in the understanding of soil response to specific excitations. The challenge is to model this multi-scale problem (see Fig.1), which requires innovation in computational science to predict flow, permeability, and nonlinear wave propagation through gas/oil-reservoirs to enhance efficient exploration, evaluation, and production as well as energy efficient processing and storage. When the study is extended to rock-fluid systems prediction of overpressure mechanisms is a problem of outmost importance, usually addressed by means of empirical approaches.

Modeling of wave propagation in dry systems is state of the art in MSM group, where the Discrete Particle Method (DEM) has been used to understand the influence of micro-structure on waves propagation in a granular soil subjected to generic stress condition. In the case of particles in a fluid, the pore pressure role can be studied numerically by tuning directly the characteristics of the fluid phase. Two possible approaches will be evaluated, DEM solid particles coupled with Smoothed particle Hydrodynamics (SPH) or with Lattice Boltzmann (LB). Both method are well established in the MSM group and have been applied to reproduce a wide range of phenomena. SPH is a meshless method, originally developed for astrophysics, where the field properties are smoothed between fluid points, while LB is based on the collision of ideal fluid particles.

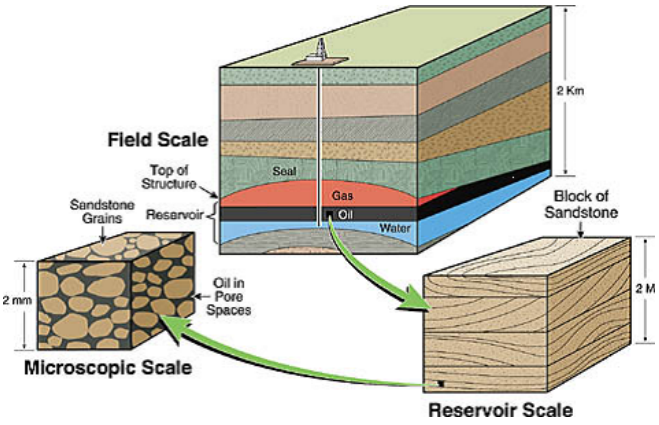

Figure 1: Schematic of multi-scale soil structure.

Plan

The study will include the following steps:

- comparison of the two methods and their advanatges-drawbacks for the study of wave propagation
- simulation of wave propagation in a simple only-fluid framework
- simulation of wave propagation in a system made of (random) particles in a fluid matrix with focus on the pore pressure

The M.Sc project may include an internship period in the Geophysical laboratories at ENI in Milan (IT) to run complementary experiments.

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The project is developed in collaboration with ENI.