**Unconventional resources: Petrophysical properties of oil and gas shales and induced microseismicity from hydraulic fracturing**

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Source rocks (self-resourcing shales), such as the Bakken, Kimmeridge or Vaca Muerta oil shales, can be described by a porous anisotropic medium composed of illite/smectite and organic matter. We assume that the rock has a very low permeability and pore-pressure build-up occurs. We consider a basin-evolution model with constant sedimentation rate and geothermal gradient. Kerogen-oil conversion starts at a given depth in a volume whose permeability is sufficiently low so that the increase in pressure due to oil generation greatly exceeds the dissipation of pressure by flow. Assuming a first-order kinetic reaction, with a reaction rate satisfying the Arrhenius equation, the kerogen-oil conversion fraction is calculated. Pore-pressure changes affect the dry-rock stiffnesses, which has an influence on seismic velocities. The properties of the kerogen-oil mixture are obtained by assuming that oil is an inclusion in a kerogen (porous) matrix. Then, we use Backus and Gassmann equations to obtain the seismic velocities of the source rock as a function of depth, pressure, oil-gas saturation and propagation direction. The examples consider the North-Sea Kimmeridge shale and samples of the Bakken-shale data set, with a kerogen pore infill. Seismic techniques, such as wave modeling, traveltime tomography and microseismic imaging of hydraulic fracturing, are briefly outlined to assess the saturation of oil and the presence of fractures.

Unconventional resources such as oil and gas, extracted from shales, started to be rentable after the use of stimulation techniques that increase the formation permeability. The so-called “fracking” or hydraulic fracture stimulation is based on high-pressure fluid injections in boreholes to generate fractures and microcracks. The related induce seismicity can be used to locate these high permeable flow paths and obtain the permeability tensor. The whole process requires to understand how the pressure field around the well evolves with the injection rate and how permeability is modified as a function of pressure. This leads to non-linear differential equations for the pressure. The physics of fluid diffusion in anisotropic porous media is based on Biot’s theory of poroelasticity. Then, solutions of the pressure equation can be semi-analytical and numerical. After the pressure field is established, microseismic field are emitted and recorded at the surface and nearby wells. The emission time depend on the type of source, i.e., tensile and shear, and the data processing on the basis of the pressure solution can give information about the fractured zone and magnitude of the permeability (tensor) components of the shale. The same technique can be applied to CO2 monitoring problems related to storage in depleted reservoirs.