Title: The impact of the flow field heterogeneity and of the injection rate on the pore-scale reaction rates in carbonates

Joao Nunes

Abstract: We present a Lagrangian method to simulate carbonate dissolution at the pore scale directly on the voxels of 3D micro-CT images. Rock-fluid interaction is modelled using a three-step approach: solute advection, diffusion and reaction. Advection is simulated with a semi-analytical pore-scale streamline tracing algorithm; diffusion by random walk is superimposed; and the reaction rate is defined by the flux of particles through the pore-solid interface. We derive a relationship between the local particle flux and the independently measured batch calcite dissolution rate. We validate our method against a dynamic imaging experiment where a Ketton oolite is imaged during CO2-enriched brine injection at reservoir conditions. The increases in porosity and permeability are predicted accurately and the spatial distribution of the dissolution front is replicated. The experiments and simulations are performed at a high flow rate, in the uniform dissolution regime (Péclet >>1 and Damköhler <<1). The sample averaged reaction rate is one order of magnitude lower than measured in batch reactors. This decrease is caused solely by the transport-limited flux of solute to the solid surface in a heterogeneous flow field.

To study the impact of the pore-space complexity (defined by the hydraulic tortuosity) we repeat the simulations in a beadpack and in a more complex carbonates, an Estaillades limestone. We show that the average reaction rate depends on the heterogeneity of the rock. Dissolution is not only controlled by the ratios between advection, diffusion and reaction, but also by the degree of heterogeneity of the flow field.

Biography: B.Sc. and M.Sc. in physics, Federal University of Rio de Janeiro, Brazil
Reservoir geophysicist with Petrobras since 2006.
PhD student at Imperial since December/2012.