Wettability - Combine the macroscopic approach to pore-scale analysis

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Abstract. Fluid flow in porous media is known to be ruled by relative permeability. The relative permeability itself is dramatically impacted by the wettability state of the medium. Wettability refers to the relative preference of a solid material for one fluid in a diphasic or multiphasic system. Despite its great impact in oil recovery, a proper characterization inside the rocks, of its effect has never truly been established: until now wettability in porous media remains poorly understood. The widely used way to determine wettability in the oil industry is through empirical indices given by the Amott test or the USBM test. Those experiments give a very global idea of a given porous material's wettability, but indices do not reflect the complexity of a mixed wettability state nor the physical manifestation of wettability in the pore space. In this work, we intend to establish a correlation between measured Amott indices and the corresponding manifestation at the pore scale, to known physical properties at the pore scale, in a rock/oil/brine system.

The Amott test is usually performed on centimeter sized samples. The direct observation of fluid in the pore space is allowed by X-ray micro computed tomography (μ-CT), which give access to the very pore space in three dimensions. In order to ensure the acquisition of entire samples at a typical resolution from 2 to 3 micrometers per pixel, it is needed to work on millimeter sized sample diameters.

Here, the Amott tests are conducted on twin samples: a centimeter sized and a millimeter sized sample: respectively termed "classical Plug", and "μ-Plug". The use of twin samples allows to make sure that we compare the same wettability state. While the produced fluid volume is simply recorded on classical plugs according to Amott standard, we perform X-ray μ-CT acquisition on the μ-Plug at each endpoint of the Amott process: Primary drainage, Spontaneous Imbibition, Forced Imbibition, Spontaneous Drainage, and Forced Drainage. Obtained data allows measurements of fluid's saturation on the μ-Plug through image processing, leading to Amott indices to be compared with the classical Plug. Moreover, we propose here for the first time a deeper analysis to relate indices to corresponding pore scale properties. We intend to associate the Amott wettability indices to physical characteristics such as the fluid distribution and the interfacial properties, accounting for the porous medium complexity. In the Digital rock Physic field, this study may lead to improvement of existing simulation by including the wettability to models.