Hagen-Poiseuille, Darcy and 3D NS numerical modeling of pressure drops in micro-channels with integrated pillars

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High-pressure micro-models are very useful tools to directly visualize the pore-scale fluid distribution and displacement, by injecting for example CO_2 into a water-saturated micro porous media at the geological reservoir conditions. ICMCB researchers have performed fluid flow experiments performed within a well-designed two-dimensional pore network inside the high-pressure silicon/Pyrex micro-models. Obviously, such micro-models have a low pertinence with respect to the local complexity encountered in the 3D porous media of the geological formations and the measurements of the local velocity field always remain a non-resolved challenging problem, especially at high pressure and high temperature. However, they can take advantage of their 2D characteristics to observe, for the first time in real p,T conditions, the behavior of the two-phase distribution at different operating conditions. The combination between flow rate and pressure measurements and the video recording of the pore network, can be then used to capture some of the key mechanisms at a typical pore scale of a few tens of micrometers. Besides the experiments, numerical modeling of such experiments has been done using the PHOENICS software from CHAM LTD. First to validate the numerical model which will be used at ICMCB, it has been tested against a thorough published experiments of water injection in micro-model at various Reynolds number, and plots arrangements.

Using the Phoenics code, we started with 2D models but found out that the pressure drop was way off from the one obtained through experiments. This is mainly due to the short height of channel which makes friction from top and bottom walls a substantial effect. Therefore we resorted to a full three dimensional calculations. These calculations are costly due the large amounts of pillars in the channel. These 3D computational models reproduced satisfactorily the expected pressure drop. However due to the small height of the rectangular channels used in these study, we have investigated the 2D-Helle-Shaw formulation and found a very good agreements with the 3D models with a much lower CPU cost.