The role of recirculation zones on non-Fickian transport phenomena in 3D porous media

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## Description

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In groundwater engineering, remediation techniques based on the injection of nano/particles have enjoined a particular success. Pore-scale numerical simulations are a powerful tool to study transport of solutes and colloidal suspensions in porous media, and are used to derive constitutive laws tune macro-scale models.

In the Eulerian framework, the influence of the pore space geometry on transport phenomena was investigated thanks to computational fluid dynamics pore-scale simulations. Three different 3D periodic arrangements of spherical grains were used, namely face-centered-cubic (FCC), body-centered-cubic (BCC), and sphere-in-cube (SIC) packings, [1].

In Stokes regime, the transport of a conservative tracer and of particles undergoing instantaneous heterogeneous reaction were both investigated and the resulting outflow concentration (breakthrough curves) were analyzed: even if the porous media have the very same grains shape and size and the same porosity, the breakthrough curves present noteworthy differences, such as an enhanced tailing and early arrival times (Fig. 1).

The anomalous (non-Fickian) transport observed was indeed correlated with the peculiarities of the pore-space and to the presence of recirculation zones above all, [2]. The recirculation zones were detected at low Reynolds numbers and various methods, first of all a streaklines visualization (Fig. 2), were adopted to describe qualitatively and quantitatively such zones. The analysis of the angle formed by velocity and vorticity vectors proved to be particularly effective in the detection of recirculation zones, [1].

At last, simulating the transport of particles undergoing instantaneous heterogeneous reactions, the role played by the medium structure is evident also evaluating the deposition efficiency coefficient, as its behavior clearly depends on the grains packing adopted, [3-5].

After more than fifty years, the study of anomalous transport in porous media still offers a breeding ground for researches in many different fields [6]. Since in the groundwater framework the determination of this macro-scale parameter is a key factor to design effective remediation techniques, this work tries to exploit the potentiality of computational fluid dynamics to tackle the problem from the pore-scale, exploiting a practical approach.