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# Microfluidic and numerical investigation of recirculation induced reaction hot spots in a porous media analog

*Monday, 31 May 2021 10:55 (15 minutes)*

While flow in porous media systems, such as in groundwater and rock fracture flow, is usually laminar (Re < 500), it has been increasingly recognized that recirculating flow structures can appear in these systems even at Re numbers less than one [1,2]. Furthermore, the structure of porous media leads to fluid stretching and folding that dramatically alters the fate of solutes, even in the absence of inertial forces and recirculating (vortical) flows [3]. These conditions should operate in tandem to significantly impact mixing and reaction in porous media, processes that are central to the fate of groundwater contaminants and biogeochemical cycling of nutrients. Previous work with a chemiluminescent reaction at a straight channel cross intersection showed that 3D vortical flow structures form and create reaction hot spots for Re numbers as low as 100 [4]. Another study showed that vortical flow structures can control transport processes even in low Re number (Re « 1) porous media flow, but further work is needed to examine how recirculating flows influence mixing and reaction in porous systems [5]. The overarching goal of this work is to identify the physical (pore structure), hydrodynamic (Re), and chemical (reaction rate) conditions where recirculating flows create reaction hot spots in a porous media.

Here, we combine 3D pore-scale numerical simulations and microfluidic experiments with a bimolecular chemiluminescent reaction to study the formation of recirculation induced reaction hotspots in low to moderate Re number flows. We use a microfluidic channel as a porous media analog where two reactants are injected into separate channels that converge to a central channel containing a sequence of pillars that represent grains of a porous media. By adjusting the flow condition (Re) and spacing of the pillars, recirculation can be readily induced within the space between the pillars. The apperance of the reaction hot spots then depends on the interplay between the factors creating recirculating flow, and the kinetics of the chemical reaction. The results of this work show that the critical Re to initiate recirculation is sensitive to pore geometries and well within the range of flow conditions common to natural soils and fractures. We also demonstrate that even once recirculation has formed, there is an optimal flow condition which enhances the reaction rate, which is controlled by the balance of flow velocity against reaction time scale. These results imply that typical soil porous media geometries, hydrodynamic conditions, and geochemical reactions will readily create vortical structures that induce reaction hot spots which will play a significant role in many natural porous media and fractured systems. During mineral precipitation and dissolution for example, recirculation induced reaction hot spots may drive preferential reaction in certain locations, which will influence evolution of porosity as the reactions proceed.

## Time Block Preference

Time Block C (18:00-21:00 CET)

## References

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**Primary authors:** CHEN, Michael (University of Minnesota - Twin Cities); LEE, Sang; Prof. KANG, Peter (University of Minnesota - Twin Cities)

**Presenter:** CHEN, Michael (University of Minnesota - Twin Cities)

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