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Reactive mixing in heterogeneous porous media flows: scalar gradient distribution, spatial intermittency and temporal scaling of effective reaction kinetics TANGUY LE BORGNE, Université de Rennes 1, MARCO DENTZ, IDAE-CSIC Barcelona, EMMANUEL VILLERMAUX, Université Aix-Marseille — Reactive mixing processes play a central role in a range of porous media systems, including CO2 sequestration operations, reactive geothermal dipoles, biofilms, or flow-through reactors. Many of these reactions are limited by fluid mixing processes that bring the reactants into contact. Hence, the temporal dynamics of effective global reactivity is determined by the creation of concentration gradients by fluid stretching and their dissipation by diffusion. From the analysis of the elongation and aggregation of lamellar structures formed in the transported scalar fields, we derive analytical predictions for the probability density functions of scalar gradients in heterogeneous Darcy flows over a large range of Péclet numbers and permeability field variances. In this framework, we show that heterogeneous Darcy fields generate highly intermittent concentration fields, as manifested by the spatial scaling of structure functions. The resulting effective reaction rates display a range of temporal behaviors that depend on the degree of heterogeneity. In the large Damköhler limit, we derive analytical expressions for these temporal scalings in the different regimes that arise when exploring the Péclet number space. We generalize these results for different random flows.

Tanguy Le Borgne
Université de Rennes I

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