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Characterization of channeling phenomena in pore-scale flow fields

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Heterogeneity of pore structures is recognized as a key element for the formation of preferential flow paths across permeable media. Understanding the mechanisms driving flow to display pore-scale patterns characterized by focused and high-velocity channels is critical to underpin the mechanisms that constitute the signature of documented short and/or exceedingly long travel times of dissolved chemicals migrating through the fluid flow. Here, we investigate the occurrence of channeling phenomena through a set of high-resolution and detailed numerical simulations of single-phase, fully saturated flow in randomly-generated, three-dimensional porous samples. We focus on the role played by (i) the spatial correlation of the pore space and (ii) a characteristic Reynolds number of the flow taking place in such structures. These elements affect the way velocity is distributed across the range of local sizes of the heterogeneous void space. The study of velocity clusters (i.e, groups of adjacent cells characterized by a prescribed range of velocity values) allows us to characterize fast channels in terms of their length and cross-sectional area.