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Flow heterogeneity impact on dissolution reaction behavior in geologic porous media

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Two common structural patterns left by dissolution reactions in practical applications such as carbon sequestration are (1) uniform, in which the reaction spreads evenly throughout the medium and the reaction rate is relatively close to that measured in batch; and (2) wormhole, in which the reaction etches conductive pathways and the reaction rate is much lower than its batch measurement. The development of these patterns can be modeled from dimensionless transport (Peclet, Pe) and reaction (Damköhler, Da) characteristics. Specifically in dissolution behavior diagrams, one expects uniform dissolution in reaction-limited scenarios (low Da) and wormhole dissolution in transport-limited and advection-dominated conditions (high Da and Pe). However, in heterogeneous flow fields–characterized by contrasting fast velocity channels and stagnant flow regions–such dissolution behavior models often misclassify dissolution behavior. We hypothesize that flow heterogeneity, in addition to Pe and Da drives dissolution behavior and can be used to infer the reaction rate of the medium. In this work, we perform a meta-analysis of existing experimental studies on pore-scale dissolution in porous media to quantify the impact of flow heterogeneity. First, we collect the reported Pe, Da and reaction rates from existing studies and record the observed dissolution pattern. Next, we quantify each system's initial flow heterogeneity in dimensionless metrics and demonstrate the influence of flow heterogeneity on observed reaction rates. Lastly, the dimensionless flow, transport, and reaction metrics are used to parameterize a generalized linear model that can predict the reaction rate and classify the dissolution behavior. The findings of this work elucidate the emerging characteristics that control dissolution behavior during typical conditions for CO2 sequestration in heterogeneous geologic media.

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Participation

Online

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