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The impacts of micro-porosity and mineralogical texture on fractured rock alteration

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Intrinsic heterogeneities of the bordering matrix complex fracture alteration resulting from the preferential dissolution of fast-reacting minerals, which generates an altered layer (AL) as a diffusion barrier for the subsequent reactions. The thickness and spatial variations of the AL influence mass transfer across the interface, and the hydraulic and mechanical properties of the fractured medium. A real-rock based microfluidic experiment reported spatial variations in AL thickness despite the initially smooth fracture surface, suggesting the controls of matrix heterogeneity on AL development. However, the respective contribution of structural and mineralogical heterogeneity is still poorly understood, and is the focus of this study. Using the microfluidic experimental data and a micro-continuum reactive transport model, we systematically evaluated how micro-porosity and mineral texture impact AL development. Our simulation results highlight that micro-porosity plays an important role in promoting diffusion in the matrix and thus AL thickening. Ignoring these effects can result in an underestimation of 44.4% in the overall reaction. Meanwhile, the spatial variations in AL thickness are found to have a similar characteristic length to the reactive mineral clusters. Not considering these spatial variations in AL development is manifested as an underestimation of hydraulic aperture enlargement by 36.4 μm. These effects may be further amplified when the chemical and mechanical processes are coupled.