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Qualitative modeling of etch-pit formation (dissolution) on the K-feldspar surface through phase-field approach

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Estimating the porosity and permeability of rocks is a necessary component of reservoir modeling. Feldspar dissolution is a widespread phenomenon in clastic bedrock reservoirs located in petroleum-bearing zones, affecting porosity, permeability, and thus reservoir quality [1]. We adopt a phase-field model to the dissolution of K-feldspar (Orthoclase) in the present work [2]. This leads in the formation and growth of etch pits, which vary in size and shape depending on the crystallographic orientation of the feldspar grains. We begin by calibrating the anisotropic model parameters to account for anisotropy in the surface energy and particle detachment kinetics at the feldspar-water interface. Calibration is accomplished by simulating the free growth of an etch pit in a single feldspar crystal and digitally replicating the formation and relative rates of the pits' different faces based on earlier experimental and numerical findings [3]. Following that, the calibrated model is used to simulate etch pitting in a variety of digital multi-grain packs with varied proportions of quartz and feldspar grains, analogous to sandstones. Furthermore, the digital grain packs are used to perform computational fluid dynamics analysis on the progressively pitted quartz-feldspar sandstones to determine their permeabilities. The proposed model is capable of recreating natural pit morphologies. The numerical data sets created are evaluated to determine the effect of etch pitting on the permeability, porosity, and mineral composition of sandstones, which is experimentally improbable or time consuming. Finally, we show the model's capabilities using novel post-processing and visualization techniques.

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