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Deep Learning Prediction of Reactive Dissolution in Porous Media

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Reactive dissolution of solid minerals in porous media is a critical process underlying numerous subsurface applications, including carbon capture and storage (CCS), geothermal reservoir management, and oil & gas recovery. However, direct numerical simulators for modelling reactive flow and mineral dissolution often prove computationally prohibitive. To address this challenge, deep-learning methods - commonly based on convolutional neural networks (CNNs)—have emerged as promising alternatives. Yet, existing data-driven approaches typically focus on predicting velocity fields, overlooking the temporal evolution of rock structure during dissolution.

In this study, we introduce a novel deep-learning framework that integrates both spatial and temporal information to forecast the future states of a dissolving porous medium at a fixed time-step horizon. By leveraging sequences of past states as input, our method accurately captures the evolution of pore structure and mineral dissolution over time. When benchmarked against traditional numerical simulators and state-of-the-art data-driven methods, our approach demonstrates both higher predictive accuracy and remarkable computational efficiency. Notably, it achieves a speedup of approximately 10^4 compared to conventional numerical solvers, offering a powerful tool for large-scale, time-dependent simulations in the porous media community.

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References

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