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Predictive digital twins of geologic heterogeneous material for predicting mechanical properties

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We investigate influences of material heterogeneity (e.g., mineralogy, cement types, organic content) and the spatial distribution of these characteristics on mechanical rock properties (e.g., reduced elastic modulus). This type of heterogeneity is quite ubiquitous in sedimentary rocks where energy storage and recovery has been investigated. Since experimental data acquisition is extremely costly and labor-intensive, we propose the use of digital twins to overcome this problem. We train our digital twins using synthetic data produced by nanoindentation simulation. Our digital twins are built upon a combination of continuous conditional generative adversarial networks [1,2] and physics-informed neural networks [3] for multi-modal modeling to account for multiscale aspects of rock behaviors. We then validate our digital twins through a set of real experiments. This work will help us better understand mechanical responses of heterogeneous geomaterials and ultimately design safe and cost-effective CO2 and/or H2 storage.

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