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Influences of fracture network topology on incipient karst formation in carbonate rocks

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Karst aquifers are highly heterogeneous hydrosystems where the geological structures that control the main flow paths exhibit complex geometry and topology. To get a better understanding of hydrodynamics of karst aquifers, it is important to understand how karst conduits form in response to carbonate dissolution in intricate fracture networks. The perturbation induced by aperture growth may have significant consequences on the scaling behavior of fracture network permeability. Therefore, we develop a numerical model, coupling the hydraulic and chemical processes governing the karstification processes, to investigate the influence of structural heterogeneities on the generation of incipient karst and better assess the evolutionary trajectories of natural karst systems.
The evolution of conduit aperture is estimated based on a quasi-steady approximation of the sequentially coupled processes. The reactive transport problem is then solved on a synthetic discrete fracture network model. We consider realistic geometry and topology of natural joint networks. Initial aperture variability of joints obeys log-normal distributions. Previous simulations showed the importance impact of the fracture network topology on flow organization within the network. Here, the influence of the additional structure complexity induced by aperture variability on dissolution patterns is investigated. Results show that conduit networks of very different geometry emerge when different realizations of aperture models are imposed onto the same fracture network. Simulations also showed that the favored locations for the development of dominant conduits depend highly on the hydraulic connection between multiple dissolution paths competing for flow. The impact on the aperture growth on the flow exchange between dissolving fractures and ambient matrix is also considered.