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The formation and growth of wormholes in mineral-cemented fractures

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A number of experimental and numerical studies of dissolution in fractured or porous rock have established that the evolving topography of the pore space depends strongly on the fluid flow and mineral dissolution rates. Remarkably, there exists a parameter range in which positive feedback between fluid transport and mineral dissolution leads to the spontaneous formation of pronounced channels, frequently referred to as wormholes. Most of the previous studies of the wormholing in fractures considered the case of a fracture formed in soluble rocks, and the aperture growth due to the dissolution was assumed to be effectively unlimited.

Here we consider a different case, where a fracture is formed in insoluble rocks but it is partially filled with a soluble (e.g. carbonate) cement. In such case, the aperture growth due to the dissolution is limited, which significantly influences the pattern formation in the system. We show that the instability leading to the formation of the wormholes is still present in such case, however the most unstable perturbation wavelength is shorter and thus the number of initially created wormholes considerably larger than in the case with unlimited aperture. Additionally, the reactive front is moving faster and the competition between the wormholes is much weaker in the limited aperture case. These factors are shown to affect the permeability evolution and the breakthrough time in a non-trivial manner.