EGU22-8971, updated on 11 Aug 2022
https://doi.org/10.5194/egusphere-egu22-8971
EGU General Assembly 2022

A Numerical Study of Wormhole Formation and Growth in Homogeneous and Heterogeneous Carbonate Rocks

Kenji Furui[1] and Keita Yoshioka[2]
[1]Waseda University, Shinjuku-ku, Japan (furui@waseda.jp)
[2]Helmholtz Centre for Environmental Research-UFZ, Germany (keita.yoshioka@ufz.de)

Wormholes are an effective fluid conduit that dominate the flow path in karst aquifers and are artificially induced in geo-energy applications through acid injection. As acidic fluids infiltrate geologic formations, they react with the minerals in the formation. The reaction localizes and forms a dendritic dissolution pattern under certain conditions, known as the reaction infiltration instability. This instability is instigated by material heterogeneities in most computational models. However, studies have demonstrated that injection of water into a homogeneous plaster can initiate and grow wormholes. In this study, we show that material heterogeneities suppress the wormhole growth in carbonate rocks compared with a homogeneous counterpart. Wormholes were numerically simulated through injection of a strong acid (hydrochloric acid) under both homogeneous and heterogeneous permeability fields using a phase-field approach. The phase-field variable represents calcite dissolution in a diffused manner and is coupled with a reactive flow model assuming convective and diffusive acid transport in the liquid phase and significantly high surface reaction rate, which emulate typical high-rate matrix acidizing treatments in carbonate reservoirs. Heterogeneous permeability fields localize the flow in high-permeability domains and enhance the splitting and branching of wormholes. The length of the dominant wormholes can be suppressed as an increasing amount of acid infiltrates into the branched wormholes. Our findings indicate that material heterogeneities should not be treated as a trigger for wormholes in the numerical simulation but as one of the parameters to control their nucleation and growth.