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Modelling and simulation of reactive dissolution during acidization of fractured carbonate rocks

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Acidizing is a commonly used stimulation treatment for carbonate reservoir by injecting acid into near-wellbore formation to remedy the damage and to create operational-optimal deep-penetrating and narrow high permeability channels, termed as wormholes, by mineral dissolution. Wormhole formation in un-fractured matrix has been widely studied by numerical modelling, but little work has been done for fractured cases which may cause wormholes to propagate quite differently. In this study, a continuum model with explicit fractures is developed, where the governing equations are discretized by the finite-volume method. This model produces the correct dissolution patterns on a 2-D un-fractured domain discretized by Delaunay triangulation. Then it is used to examine wormhole formation in cases with single, multiple, and complex fractures, including characteristics such as fracture orientation, aperture, connection, and distribution. It is found that neither the volume of acid required nor the dissolution structure is affected by fractures with small aperture. If the fracture aperture is large enough, the dissolution structure is dominated by the fracture distribution at intermediate injection rates but is independent with the fracture distribution at very low or very high injection rates. The presence of fractures and the increase of fracture aperture have no influence on the type of dissolution patterns. The volume of acid required to break through the core decreases with the increase of the fracture aperture, which is particularly noticeable when the dominate wormhole is created. For the fractured porous media of not well-connected fractures, the final dissolution structure of wormhole is determined by the fracture and matrix porosity distributions together. As for the well-connected fractures, the matrix heterogeneity has no contribution to the creation of the wormhole, and the dissolution front propagates along the fracture trace. Finally, for the field-scale application, it is found that the optimum injection rate is almost unchanged from un-fractured medium to fractured medium if the acid-mineral reaction system is same.

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