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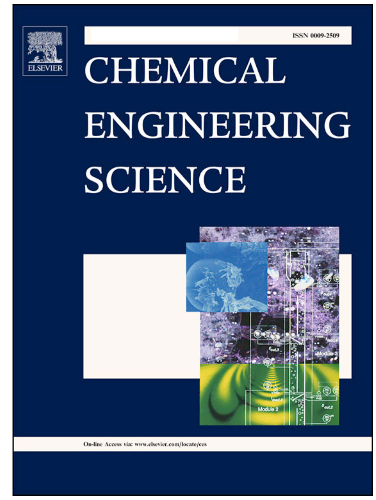

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Impact of phase saturation on wormhole formation in rock matrix acidizing

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Abstract

Studies of the rock matrix acidizing for enhanced recovery of oil or gas have entirely focused on the fully water saturated conditions. In fact, matrix acidizing can be conducted in low-water-cut oil-production wells without pre-flushing of water or in high water production by injecting gas or oil ahead of the acid injection. These conditions yield a multiphase system, where the dynamics of acid transport and reactions can be altered by the presence of an immiscible phase. Against this backdrop, we present an investigation of the impact of initial saturation of an immiscible phase in the damaged zone on the efficiency of wormhole generation and growth in acidizing operations. We present a dimensionless two-phase reactive transport modelling tailored for studying the processes associated with rock acidizing. For a case study of acid injection into calcite with random porosity and permeability distribution, we show that an initial two-phase condition has positive feedback on the generation of wormholes. The results, however, indicate that the relative magnitude of reduction in the amount of pore volume of injected acid to produce effective wormholes depends on the mobility ratio, so that a higher mobility ratio facilitates a faster wormhole generation process. Under the conditions of modelling study presented, we demonstrate that in addition to the commonly used pair of Péclet-Damköhler regime identification, the mobility ratio of the displacing/displaced fluids, the relative permeability and phase condition need be accounted for in the analysis, if there are two-phase flow conditions across the target region of acidizing.

Keywords

matrix acidizing, two phase flow, reactive transport, wormholing process, rock heterogeneity

1 – Introduction

Reactions between acidic solutions and the solid phase appear in various engineering and natural subsurface processes including irrigating water discharge to aquifer systems (Valdes-Abellan et al., 2017), karst formation (Evans and Lizarralde, 2003; Zhao et al., 2013), contaminants transport in saturated and unsaturated soils (Cubillas et al., 2005; Chen et al., 2009; Nick et al., 2013; Atchley et al., 2014; Sedighi et al., 2015; Sedighi et al., 2016), radioactive waste remediation (Spycher et al., 2003), geological sequestration of carbon dioxide (e.g. Rochelle et al., 2004; Kampman et al., 2014; Islam et al., 2014; Islam et al., 2016), acid injection for enhanced oil recovery (e.g., Ghommem et al., 2015 and references therein) and acid-based enhanced geothermal systems (Portier et al., 2007;

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