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Impact of Mineral Heterogeneity on Wormhole Propagation in Matrix Acidizing and the Shortcomings of the Damkholer Number-based Designs

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SUMMARY

Sustainable and successful exploitation of the underground resources (oil, gas, geothermal energy, water, etc.) is intimately dependent on the performances of the well and the near-wellbore to optimally deliver these resources. In carbonate reservoirs, acid stimulation by matrix acidizing has been a method of choice to restore and/or improve well productivity and/or injectivity index. An optimal reaction rate leads to a dissolution regime for which wormholes connect the wellbore and the initial reservoir permeability. The success of this operation depends mainly on the permeability distribution, injection rate, mineral reaction rates and the chemical speciation of reservoir/acid.
Introduction

Sustainable and successful exploitation of the underground resources (oil, gas, geothermal energy, water, etc.) is intimately dependent on the performances of the well and the near-wellbore to optimally deliver these resources. In carbonate reservoirs, acid stimulation by matrix acidizing has been a method of choice to restore and/or improve well productivity and/or injectivity index. An optimal reaction rate leads to a dissolution regime for which wormholes connect the wellbore and the initial reservoir permeability. The success of this operation depends mainly on the permeability distribution, injection rate, mineral reaction rates and the chemical speciation of reservoir/acid.

In this work we present a newly developed reactive transport simulator for matrix acidizing in carbonate reservoirs (Sbai, 2014). The main distinguishing features of this simulator lie in its capability to handle a complete and substantially much larger reaction networks than other recently published matrix acidizing simulators. Indeed, in many available simulators only one simple 'lumped' dissolution mechanism reaction is considered assuming homogeneity of the mineral distribution at the pore surfaces. These models oversimplify the complexities of water-rock interactions and the dependence of the reactivity on chemical equilibrium thermodynamics and kinetics principles. This approach had allowed engineers to design matrix acidizing following the well-known Damköhler number.

First, the model was verified and validated with others (Fig.1) when considering the dissolution of one single mineral phase. We show however, that mineral heterogeneity can dramatically change the dissolution regimes and the occurrence of the wormholing regime leading to question on the validity of the Damköhler number field based designs. In particular, we show on the basis of two different types of mineralogical assemblages (with/without aluminosilicate mineral phases) that precipitation of secondary phases could significantly retard the occurrence of the wormholing regime.

References


Figure 1 Transition of a simulated dissolution patterns for increased acid injection flow rates and decreasing Damköhler numbers when considering a single mineral phase. (a) face dissolution, (b,c) conical wormholes, (d) dominant wormholes, (e) ramified wormhole, and (f) uniform dissolution.