45e Two-Scale Continuum Model for Simulation of Wormhole Formation in Carbonate Acidization

Ramesh Raju Mudunuri, Mohan K. R. Panga, Philippe Tardy, Murtaza Ziauddin, and Vemuri Balakotaiah

A two-scale continuum model is developed to describe transport and reaction mechanisms in reactive dissolution of a porous medium and used to study wormhole formation during acid stimulation of carbonate cores. The model accounts for pore level physics by coupling local pore scale phenomena to macroscopic variables (Darcy velocity, pressure and reactant cup-mixing concentra)tion) through structure-property relationships (permeability-porosity, average pore size-porosity etc.), and the dependence of mass transfer and dispersion coefficients on evolving pore scale variables (average pore size and local Reynolds and Schmidt numbers). The gradients in concentration at the pore level caused by flow, species diffusion and chemical reaction are described using two concentration variables and a local mass transfer coefficient. Numerical simulations of the model show that the model captures dissolution patterns observed in the experiments. A qualitative criterion for wormhole formation is developed and it is given by Lambda is approximately unity, where Lambda= sqrt (Keff.DeT)/u0 . Here,Keff is the effective volumetric dissolution rate constant,DeTis the transverse dispersion coefficient and u0 is the injection velocity. The model is used to examine the influence of the level of dispersion, the heterogeneities present in the core, reaction kinetics and mass transfer on wormhole formation. The model predictions are favorably compared to laboratory data.