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Acidization of shales with calcite cemented fractures

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Investigation of cores drilled from shale formations reveals a relatively large number of calcite-cemented fractures. Usually such fractures are reactivated during fracking and can contribute considerably to the permeability of the resulting fracture network. However, calcite coating on their surfaces effectively excludes them from production. Dissolution of the calcite cement by acidic fluids is investigated numerically with focus on the evolution of fracture morphology. Available surface area, breakthrough time, and reactant penetration length are calculated.

Natural fractures in cores from Pomeranian shale formation (northern Poland) were analyzed and classified. Representative fractures are relatively thin (0.1 mm), flat and completely sealed with calcite. Next, the morphology evolution of reactivated natural fractures treated with low-pH fluids has been simulated numerically under various operating conditions. Depth-averaged equations for fracture flow and reactant transport has been solved by finite-difference method coupled with sparse-matrix solver. Transport-limited dissolution has been considered, which corresponds to the treatment with strong acids, such as HCl.

Calcite coating in reactivated natural fractures dissolves in a highly non-homogeneous manner - a positive feedback between fluid transport and calcite dissolution leads to the spontaneous formation of wormhole-like patterns, in which most of the flow is focused. The wormholes carry reactive fluids deeper inside the system, which dramatically increases the range of the treatment. Non-uniformity of the dissolution patterns provides a way of retaining the fracture permeability even in the absence of the proppant, since the less dissolved regions will act as supports to keep more dissolved regions open. Evolution of fracture morphology is shown to depend strongly on the thickness of calcite layer – the thicker the coating the more pronounced wormholes are observed. However the interaction between wormholes is the strongest when coating thickness is a few times larger than the initial aperture of the fracture. This leads to formation of favorable complex networks of wormholes which provide adequate transport of reactive fluids to fracture surfaces and – at the same time – are capable of supporting fracture surfaces. As a conclusion, acidization of the reactivated fractures with hydrochloric acid seems to be an attractive treatment to apply at fracking stage or later on as EGR.

The results contribute to the discussion on the use of acidization to enhance the gas production in the shale reservoirs. This communication stresses the importance of the dissolution of calcite cement in natural fractures in shale formations, which are initially sealed and become reactivated during fracking. While this research is based on the analysis of fractures in the Pomeranian shale basin its results are general enough to be applicable to different formations worldwide.