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Permeability evolution due to dissolution of natural shale fractures reactivated by fracking

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Investigation of cores drilled from gas-bearing shale formations reveals a relatively large number of calcite-cemented fractures. During fracking, some of these fractures will be reactivated [1-2] and may become important flow paths in the resulting fracture system. In this communication, we investigate numerically the effect of low-pH reactive fluid on such fractures. The low-pH fluids can either be pumped during the initial fracking stage (as suggested e.g. by Grieser et al., [3]) or injected later, as part of enhanced gas recovery (EGR) processes. In particular, it has been suggested that CO_2 injection can be considered as a method of EGR [4], which is attractive as it can potentially be combined with simultaneous CO_2 sequestration. However, when mixed with brine, CO_2 becomes acidic and thus can be a dissolving agent for the carbonate cement in the fractures.

The dissolution of the cement leads to the enhancement of permeability and interconnectivity of the fracture network and, as a result, increases the overall capacity of the reservoir. Importantly, we show that the dissolution of such fractures proceeds in a highly non-homogeneous manner - a positive feedback between fluid transport and mineral dissolution leads to the spontaneous formation of pronounced flow channels, frequently referred to as "wormholes". The wormholes carry the chemically active fluid deeper inside the system, which dramatically speeds up the overall permeability increase.

If the low-pH fluids are used during fracking, then the non-uniform dissolution becomes important for retaining the fracture permeability, even in the absence of the proppant. Whereas a uniformly etched fracture will close tightly under the overburden once the fluid pressure is removed, the nonuniform etching will tend to maintain the permeability since the less dissolved regions will act as supports to keep more dissolved regions open.

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