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Dissolution of cemented fractures in gas bearing shales in the context of CO_2 sequestration

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Carbon dioxide has a stronger binding than methane to the organic matter contained in the matrix of shale rocks [1]. Thus, the injection of CO_2 into shale formation may enhance the production rate and total amount of produced methane, and simultaneously permanently store pumped CO_2. Carbon dioxide can be injected during the initial fracking stage as CO_2 based hydraulic fracturing, and/or later, as a part of enhanced gas recovery (EGR) [2]. Economic and environmental benefits makes CO_2 sequestration in shales potentially very for industrial-scale operation [3].

However, the effective process requires large area of fracture-matrix interface, where CO_2 and CH_4 can be exchanged. Usually natural fractures, existing in shale formation, are preferentially reactivated during hydraulic fracturing, thus they considerably contribute to the flow paths in the resulting fracture system [4]. Unfortunately, very often these natural fractures are sealed by calcite [5]. Consequently the layer of calcite coating surfaces impedes exchange of gases, both CO_2 and CH_4, between shale matrix and fracture.

In this communication we address the question whether carbonic acid, formed when CO_2 is mixed with brine, is able to effectively dissolve a calcite layer present in the natural fractures. We investigate numerically fluid flow and dissolution of calcite coating in natural shale fractures, with CO_2-brine mixture as a reactive fluid. Moreover, we discuss the differences between slow dissolution (driven by carbonic acid) and fast dissolution (driven by stronger hydrochloric acid) of calcite layer.

We compare an impact of the flow rate and geometry of the fracture on the parameters of practical importance: available surface area, morphology of dissolution front, time scale of the dissolution, and the penetration length. We investigate whether the dissolution is sufficiently non-uniform to retain the fracture permeability, even in the absence of the proppant. The sizes of analysed fractures varying from 0.2 x 0.2 m2 up to 4 x 4 m2, together with discussion of a further upscaling, make the study relevant to the industrial applications.

While the results of this study should be applicable to different shale formations throughout the world, we discuss them in the context of preparation to gas-production from Pomeranian shale basin, located in the northern Poland.

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