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Pore-scale Analysis of Carbonate Acidification Based on CT Scan Imaging: An Experimental Investigation

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Well-stimulation techniques are designed to mitigate formation damage phenomena. Matrix acidizing, a standard stimulation method, involves injecting an acidic fluid into the formation near the well to dissolve rock matrix minerals, create dissolution channels, enhance permeability, and restore well flow. Hydrochloric acid (HCl) is the most commonly used acid for this purpose; however, its high reaction rate with carbonates can limit its penetration into the formation. To optimize acid usage and increase the depth of wormholes, it is crucial to develop stimulation fluids with additives that slow down the acid's dissolution of the rock matrix.
This study aimed to understand the impact of stimulation fluids on the rock's petrophysical and geomechanical properties. Computed microtomography (μCT) was employed to analyze the resulting wormhole patterns. Key characterizations included reactive fluid properties, carbonate rock samples, porosity and permeability measurements, rock mechanics tests, porous media flow tests, and X-ray μCT imaging.
The results revealed significant weakening and stiffness loss in the rock after acid treatment. Samples treated with 15% HCl exhibited Young's modulus values approximately 96% lower than those of the intact samples, while those treated with 15% HCl plus additives showed a 22% reduction. Conversely, the 15% HCl group displayed a Poisson's ratio 39% higher than the intact samples, compared to a 15% increase for the additive group. The uniaxial compressive strength (UCS) of the 15% HCl group was around 60% lower than that of the intact samples, whereas the additive group showed an 8% reduction. Similarly, diametral compressive strength for the 15% HCl-treated samples was approximately 17% of the UCS, while the additive-treated samples achieved about 8%.
Micro-computed tomography visually confirmed the creation of fluid flow pathways from the reservoir to the well due to acid treatment. Rock mechanics findings highlighted that samples treated with 15% HCl and additives suffered less damage to their rock matrix than those treated with 15% HCl alone.

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References

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Primary author: FARÇAL ROCHA DA COSTA, Victoria (Federal University of Pernambuco)

Co-author: JOSÉ DO NASCIMENTO GUIMARÃES, Leonardo

Presenter: FARÇAL ROCHA DA COSTA, Victoria (Federal University of Pernambuco)

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