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Effect of flow rate and fluid chemistry on Precipitation Patterns in acidified shales

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Hydraulic fracturing is an important technique used to stimulate the productivity of shale reservoirs. During the fracturing process, mineral dissolution and precipitation usually occur due to the reuse of the hydraulic fracturing fluid (HFF) in the shale reservoirs. However, the consequences of interactions between the shale matrix and the flow-back HFFs on shale matrix remain unclear. A microfluidic chip fabricated with fractured shale was used to investigate the dynamic acidification process by injecting hydrochloric acid (HCl) under pH=2, and the subsequent precipitation processes by simultaneously injecting barium chloride (BaCl₂) and sodium sulfate (Na₂SO₄) solutions under different flow rates and pH conditions. The depth of the altered zone in the shale matrix caused by acidification and the distribution of barite precipitation due to fluid mixing were observed and characterized by an optical microscope and SEM-EDS.

With the injection of HCl, the thickness of the alteration zone gradually increased, and the increase rate decreases gradually due to the increase of diffusion path . Under the condition that the total injected solution volume is fixed, the higher the injection flow rate is, the slower the increase rate of alteration zone is. When BaCl₂ and Na₂SO₄ solutions were injected under different pH conditions (pH = 2,8,11) and flow rates(q=1.2, 4, 12, 24μl/min), as the pH increases and the flow rate decreases, the precipitation rate gradually increases, and the main distribution of precipitation shifts from the acid-etched shale matrix to the shale-fluid interface near the fracture channels.

Results demonstrate that the precipitation pattern is controlled by the localized concentration of reactants and geometry of the shale matrix, depending on the injected fluid chemistry and flow condition. This study provides valuable insights into the stimulation efficiency of shale reservoirs under the coupled effects of dissolution and precipitation with different operational conditions.

Keywords: shale matrix, hydraulic fracturing fluids, acidification, barite precipitation

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