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Pore characteristics and hydraulic properties of shale samples under long-term exposure to hydraulic fracturing fluids

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Fluids-shale interactions during hydraulic fracturing alters the pore characteristics and hydraulic properties of shale, thus affecting the oil and gas recovery efficiency and the geological storage capacity of shale reservoirs. Short-term (0-1 month) and long-term (1-12 months) experiments are conducted to investigate the fluids-shale interaction behaviour during fracturing fluid injection and retention periods. The effects of fluids-rock interaction on pore characteristics and hydraulic properties are determined by characterizing the shale's mineralogy, surface morphology, pore structure characteristics, and hydraulic properties before and after the experiments. The experimental results show variability during the fluid injection and retention periods. In the short-term experiments, pyrite dissolution caused a rapid decrease in fluid pH (decreased by 1.7-5.1). In long-term experiments, feldspar and clay mineral dissolution caused a slow increase in fluid pH (increased by 0.5). The dissolution of minerals enlarged the native pores of the shale, thereby increasing the porosity, raising the average pore diameter, and increasing the gas adsorption capacity of the shale (by 14.1%). Measurements of fractal dimension D1 indicate that the pore surfaces become rougher during the short-term experiments, whereas the pore surfaces become smoother during the long-term experiments. The change in pore structure affects the hydraulic properties of the shale. In particular, the absolute permeability of the shale increased (60.0-129.1%), while the pore tortuosity decreased (26.1%-57.8%). However, as the pH rises above 4, substantial gypsum and iron hydroxide precipitation occurs, blocking shale fractures and pores. Such precipitation reduces shale porosity, hydraulic properties, and sorption capacity. On the other hand, lower pH (below 3.5) can inhibit the formation of secondary precipitation. Monitoring pH changes is, therefore, the key to improving oil and gas recovery by enhancing reservoir geological storage capacity following hydraulic fracturing.