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Numerical modeling of hydrogen sequestration in the Northwest Bearden hydrocarbon field, Oklahoma (USA)

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The Northwest Bearden hydrocarbon field in east-central Oklahoma is a promising site for underground hydrogen sequestration (UHS). The target UHS reservoir is the Silurian-Devonian age Hunton Limestone located at a depth of approximately 1200 m , which has an average thickness of 115 m, a porosity of 12%, and a permeability of 1.03 x 10^{-15} m^2. The Hunton is overlain by the Devonian-Mississippian Woodford Shale, which serves as capping aquitard. In addition to having favorable hydrogen storage properties, the Northwest Bearden field also has considerable well infrastructure from previous oil and gas operations. The goal of this study was to investigate the Northwest Bearden field's UHS potential using numerical modeling. A multi-phase fluid flow model was constructed using the CMG software and well logs obtained from the Oklahoma Geological Survey. The models employed a cyclic pumping schedule in which hydrogen was injected at a rate of 80 kg/s for 153 days with variable proportions of methane or nitrogen cushion gas, followed by hydrogen production for 213 days. The results of the models show that injected hydrogen remained within a few 100 meters of the wells rather than being broadly dispersed within the Hunton. In addition, the Woodford Shale was found to be effective at preventing the upward escape of hydrogen from the Hunton. Nitrogen was found to be a superior cushion gas to methane for enhancing hydrogen production. The models predicted that over the course of five years of injection-production, 16% of the injected hydrogen could be recovered, with increasing efficiency over time. Separate reaction path modeling was conducted using the Geochemist's Workbench software to explore the chemical effects of hydrogen injection on pore water composition and reservoir mineralogy. The model results predict very little mineral precipitation or dissolution, suggesting that the mechanical and hydrologic integrity of the reservoir would be preserved for the injection and production rates used in the models. Pore water composition was also not strongly affected, except for oxygen fugacity, which decreased by eleven orders of magnitude during hydrogen injection. Thus, the results of this study support the favorability of the Northwest Bearden site for UHS.