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Numerical Simulations of CO_2 Injection in the Altmark Natural Gas Field, Germany

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Three-dimensional numerical simulations of CO_2-injection in the nearly depleted Salzwedel-Peckensen reservoir of the Altmark gas field in North Germany were performd to study the feasibility of carbon sequestration with enhanced gas recovery (CSEGR). The natural gas in the Altmark contains 40-90% nitrogen (N_2). We have used the Peng-Robinson equation of state to investigate the properties (e.g., density and viscosity) of CO_2-CH_4-N_2 gas mixtures that will exist upon CO_2 injection into the Altmark reservoir. We found that the density of the CO_2-CH_4-N_2 gas mixture is strongly affected by the increasing CO_2 fraction and only weakly affected by N_2 fraction. However, we found that N_2 plays a significant role in controlling mixture viscosity. Therefore, approximating the gas mixture in the Altmark as a CO_2-CH_4 mixture entails little error in density relative to the actual system, but greater error in viscosity. Nevertheless, the variation in viscosity is small relative to variations and uncertainty in reservoir permeability, which together with viscosity control gas mobility in numerical reservoir simulations. Approximating the natural gas at Altmark as a CO_2-CH_4 mixture, we have modeled various injection and production strategies using a five-spot configuration. In general, breakthrough of CO_2 occurs after a few years to decades due to fast flow in the high-permeability layers. Injection strategies include varying the CO_2 injection rate from 1.6-16 kg s^{-1} along with pre-injections of water for mobility control. A modest delay in breakthrough has been observed, pointing out the need for more advanced approaches to optimize CO_2 storage and enchance CH_4 recovery when high-permeability layers are present.