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CO2 storage capacity in saline aquifers and uncertainty sensitivity analysis

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Abstract: The emission of greenhouse gasses, especially carbon dioxide (CO2) is a major contributor to the global climate and the ecological environment. Geological storage of CO2 in deep saline aquifers is currently a widely recognized method with its stable storage and strong feasibility. However, researchers focus on the CO2 storage in saline aquifers, and there are few studies on the factors affecting the long-term stable storage of CO2 in brine. Therefore, the purpose of this study is to develop a long-term storage model and evaluate the performance of CO2 storage potential. First, we applied PC-SAFT (Perturbed-Chain Statistical Associated Fluid Theory) equation of state in phase equilibrium of CO2-H2O system. Results were validated against experimental data, indicating that PC-SAFT can well describe the phase behavior. Relevant property parameters of CO2-brine mixture were then modified and incorporated in the numerical simulation model. After that, the migration and distribution of CO2 stored in deep saline aquifers were simulated, examining the contribution of each mechanism over a 1000-year time scale. The correlations between reservoir temperature, residual gas saturation, horizontal permeability heterogeneity, the ratio of vertical to horizontal permeability, and pH were analyzed using Spearman's rank correlation coefficient method. Five storage efficiency indexes, including the Stratigraphic Trapping Index (STTI), Residual Trapping Index (RTI), Solubility Trapping Index (STI), Mineral Trapping Index (MTI), and Stable Trapping Efficiency (STE), were utilized as output parameters. The results indicate that different factors have varying degrees of influence on storage efficiency at different monitoring periods and mechanisms. Residual gas saturation is the main controlling factor for STTI, RTI, and STE at 100 years. At 500 years, the ratio of vertical permeability to horizontal permeability becomes the primary controlling factor for STI, and pH emerges as the dominant factor for MTI at the 1000-year mark. This study provides a theoretical basis for evaluating CO2 storage potential in saline aquifers and selecting the optimal storage reservoir.
Keywords: Saline aquifers, CO2 sequestration, PC-SAFT, Storage capacity, Correlation analysis

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