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PROCEEDINGS

CO_2 Migration Monitoring and Leakage Risk Assessment in Deep Saline Aquifers for Geological Sequestration

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ABSTRACT

Deep saline aquifers account for more than 90% of the global theoretical geological CO_2 sequestration capacity, making them the dominant choice for large-scale CO_2 storage. These aquifers offer vast storage potential, especially in comparison to oil and gas reservoirs, which are often considered for CO_2 geological sequestration. Despite their significant storage capacity, deep saline aquifers face several challenges that hinder their practical application. In particular, the lack of adequate geological infrastructure and exploration conditions for deep saline aquifers presents major obstacles to the effective monitoring of CO_2 migration and predicting leakage risks. These challenges are compounded by the current limitations in geological understanding and the high engineering costs associated with CO_2 sequestration projects.

In this context, the need for advanced monitoring and prediction techniques for CO_2 migration in deep saline aquifers is crucial. To address this, the study outlines an innovative approach for CO_2 migration monitoring and leakage risk prediction in deep saline aquifers under the constraints of existing geological knowledge and engineering costs. The study begins by establishing a pre-existing geological knowledge database, utilizing geological exploration data, remote sensing data, and engineering data from an ongoing terrestrial saline aquifer CO_2 sequestration project. This database serves as the foundation for developing a more comprehensive understanding of the geological structures within the aquifer. Based on this knowledge, a 3D structural model, a stratigraphic model, and an attribute model are constructed. These models enable a better understanding of the subsurface structure, allowing for more accurate predictions of CO_2 migration behavior. A numerical model is then created to simulate the effects of gravitational forces and CO_2 plume behavior within the aquifer. This model incorporates real-time monitoring data, including pressure and temperature measurements, experimental solubility data under varying temperatures and pressures, and thermodynamic equilibrium calculations of fluid properties within the saline aquifer pores. The model also integrates surface gravity detection data collected at various time intervals, which further enhances the accuracy of CO_2 migration predictions. Finally, the study evaluates the current state of CO_2 leakage risk in terrestrial saline aquifer CO_2 sequestration projects through phase-based simulations and analyses. The likelihood of CO_2 leakage is assessed both in the short term and over a 30-year period, providing valuable insights into the potential risks associated with long-term CO_2 storage in deep saline aquifers. This comprehensive approach offers a crucial tool for improving the safety and effectiveness of CO_2 sequestration projects and contributes to the broader goal of mitigating climate change through geological CO_2 storage.

KEYWORDS

Deep saline aquifers; CO_2 geological sequestration; CO_2 migration monitoring; leakage risk prediction

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