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Injection-induced Overpressure Perturbation in a Layered Formation during Carbon Dioxide Storage

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Geological carbon sequestration aims at long-term storage of carbon dioxide (CO_2) in deep geological formations, and its viability depends on how much of the CO_2 can be injected into the storage formation. Estimates of the storage capacity are therefore essential to the evaluation of individual storage sites as well as the feasibility of the technology as a whole. One important limitation on the storage capacity is the lateral extent of the pressure perturbation, which is called as the radius of review of the storage project. We show that pressure dissipation into ambient mudrocks retards the lateral pressure propagation significantly and therefore increases the storage capacity. For a three-layer model of an aquifer surrounded by thick mudrocks, the basin-scale pressure perturbation is well approximated by a single-phase model. Through dimensional analysis and numerical simulations, we show that the lateral pressure propagation follows a power-law that depends on a single parameter $M \sim log_{10}(R_k R_S R_l^2)$, where R_k and R_S are the ratios of mudrock to reservoir permeability and storativity and R_l is the aspect ratio of the confined pressure plume. Both the coefficient and the exponent of the power-law are sigmoid decreasing functions of M. The M-values of typical geological storage sites are located in the sharp transition zone where the power-law is changing rapidly. The combinations of large uncertainty in mudrock properties and the sigmoid shape lead to wide and strongly skewed probability distributions for the predicted radius of review. Therefore, the determination of the mudrock properties is an important component of the site characterization, if pressure dissipation has the potential significantly increase storage capacity. After injection the pressure will continue to diffuse and the radius of review may continue to increase, which will emphasize the significance of monitoring post-injection overpressure to secure the stability of the storage formation.

Keywords: overpressure, mudrock, carbon dioxide storage, radius of review, storage capacity