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The Impact of Heterogeneities on the Evolution of Caprock Integrity Associated Only with Mineral Alterations Due to A Long-term CO_2 Intrusion

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For a long-term CO_2 geological isolation, heterogeneities in porosity and permeability of geological formation might lead to the non-uniform distribution of pressure, CO_2 plume, the mass of trapped CO_2 and so on. These non-uniforms, for the reservoir, may affect the storage capacity, injection rate etc., with respect to the caprock, may influence the migration of intruded CO_2, the change of porosity/permeability then the evolution of the integrity of caprock. Long-term caprock integrity represents the single most important constraint on the big time frame sequestration performance of CO_2 geological storage site. The evolution of caprock integrity depends on the relative effectiveness of concomitant geochemical alteration and geomechanical deformation of the caprock triggered by the CO_2 intrusion. Our study specifically focuses on the influence of heterogeneities on the evolution of caprock integrity resulted from only the mineral alterations triggered by CO_2 intrusion after the capillary breakthrough. In order to meet the problem of calculating power, a simplified 2D geometric with heterogeneities in porosity and permeability was employed, and a homogeneous, simple mineralogical composition referring to the data of Jianghan Basin of China was chosen. All the simulations were conducted using the reactive transport simulator TOUGHREACT. Analysis of simulation results reveals that: 1) heterogeneities of permeability and porosity influence the migration of intruded CO_2 within the caprock remarkably. Specific to this study, the migration was first accelerated and then retarded by the heterogeneities compared to homogenous simulation; 2) throughout the whole simulation the total amount of intruded CO_2 in heterogeneous cases are smaller than that in homogeneous case, that means the heterogeneities restrain the penetration of CO_2 into the caprock from the reservoir; 3) the effect of heterogeneities on the evolution of caprock integrity depends on the mineralogical assemblage. Limited to the data used in our study, the caprock integrity was first weakened then enhanced by the heterogeneities in a way of impacting the mineral alterations then feeding back to the change of porosity; 4) the heterogeneity may produce the preferential pathway resulting in the non-uniform concentration of CO_2, which accelerates the mineral alterations; 5) the additional heterogeneity of porosity impacts the migration of CO_2 and the evolution of caprock integrity similar to the case only permeability heterogeneity under consideration.

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Key words: Heterogeneity; Caprock; Caprock integrity; Reactive transport; TOUGHREACT

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