Numerical simulation of ground deformation during CO_2 underground storage using gas hydrate

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A carbon dioxide sequestration method (CCS) using gas hydrate has recently been proposed, in which CO_2 is stored underground in the form of CO_2-hydrate. In this method, CO_2 and seawater will react under the gas hydrate equilibrium conditions, namely, high pressure and low temperature conditions so that CO_2 is stored as a solid in a chemically stable condition. It is possible that CO_2 is stably stored compared with a conventional method using supercritical CO_2 injection. In addition, the suitable geological area for the storage would be large since the caprock is not necessary.

In the present study, a chemo-thermo-mechanically coupled analysis has been conducted to reproduce the ground deformation during CO_2 underground storage a hydrate. Solid phase (soil, hydrate) and two liquid phases (CO_2, water) are dealt with in the numerical analysis. An elastic and elasto-viscoplastic constitutive models are used for soil phase and ground deformation due to the phase change and the change of effective stress during CO_2 injection will be reproduced. As a capillary pressure- saturation relation, van Genuchten model is used. Finite element method and Newmark’ s β method is used as a discretization in space and time, respectively.

As a simulation example, laboratory tests by Tohidi et al. (2010) is simulated using one-dimensional finite element model. Tohidi et al. (2010) conducted CO_2 injection tests into water saturated glass beads specimen under pressure of 6.3 MPa and observed hydrate formation due to convection of liquid CO_2. Simulation results will be discussed regarding to the change of water pressure, CO_2 liquid pressure, saturation, effective stress, and the soil deformation during hydrate formation.

Tohidi, B. et al., CO_2 Hydrates Could Provide Secondary Safety Factor in Subsurface Sequestration of CO_2 , Environ. Sci. Technol., 44, 1509–1514, 2010.

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