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MODELING OF MULTI-PHASE TRANSPORT AND DEFORMATION PROCESSES IN SALINE AQUIFERS DURING CO_2 SEQUESTRATION

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Summary. Carbon dioxide sequestration is at the concluding and most persistent stage of Carbon Capture and Storage (CCS) procedures and a promising transition technology for the mitigation of anthropogenic greenhouse gas emissions. Currently, the modeling of various transport and reactive processes as well as deformation aspects during CO_2 injection and storage in deep geological formations is subject of worldwide research activities. Usually, the multiple coupled problems are analyzed numerically based on physically founded complex mathematical models.

In this paper, the conceptual modeling and the numerical simulation of two-phase flow in deep saline aquifers is presented. Carbon dioxide and brine represent the fluid phases assumed to be immiscible. The main numerical focus will be on isothermal transport and deformation processes in the aquifer as well as in the cap rock during CO_2 injection, and the evolution of field variables which are relevant to assess the physical behavior and the safety of the subsurface after injection stops. Dissolution and diffusion effects are neglected at this stage.

The presented approach is based on balance equations for mass and momentum completed by constitutive relations for the fluid and solid phases. To characterize the stress state in the multi-layered elastic, deformable solid matrix the effective stress principle is applied. The fluid motion is expressed by Darcy's law for two-phase flow defining appropriate constraint conditions for the partial saturations and the pressure fractions. The interaction of fluid and solid phases is illustrated by constitutive models for capillary pressure, porosity and permeability as functions of saturation.

The coupled problem under consideration will be solved using the finite element method. As the displacement vector acts as a primary variable for the solid matrix, considering the fluid motion pressure/pressure or pressure/saturation concepts are realized. The numerical algorithms are implemented into the in-house scientific code OpenGeoSys. The capabilities of the presented model as well as of the numerical tools will be illustrated on a benchmark example.