Geophysical Research Abstracts
Vol. 15, EGU2013-6079, 2013
EGU General Assembly 2013

Fault reactivation and ground uplift assessment at a prospective German CO_2 storage site

Lina Röhmann (1), Elena Tillner (1), Thomas Kempka (1), Fabien Magri (2), and Michael Kühn (1)

(1) Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Section 5.3 – Hydrogeology, Telegrafenberg, 14473 Potsdam, Germany, roehmann@gfz-potsdam.de, (2) Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, International Centre for Geothermal Research, Telegrafenberg, 14473 Potsdam, Germany

The geological storage of CO_2 in deep saline aquifers is seen as a promising measure for reducing anthropogenic greenhouse gas emissions into the atmosphere. However, generally large-scale pressure build-up as a result of CO_2 injection may impact the mechanical behaviour of reservoir, caprock and existing faults. Caprock fracturing, ground uplift, reactivation of faults or induced seismicity are inherent risks that may pose potential health, security and environmental hazards.

Within the frame of the present study we investigated the geomechanical response of a deep saline aquifer and the surrounding rocks to CO_2 storage at a prospective German CO_2 storage site by coupled hydromechanical simulations. Changes in the initial stress field due to pressure build-up as a result of CO_2 injection allow assessment of potential fault reactivation and magnitude of ground uplift.

For this purpose, a 3D geological structural model covering an area of about 100 km x 100 km in the southeastern part of the State of Brandenburg was implemented. In a first step, stratigraphic contour lines and major fault lines were digitised based on the GeotIS online cartography of the Northeast German Basin as well as geological maps of the German State of Brandenburg, using the Petrel software package [1-3]. The 3D regional-scale model comprises several stratigraphic units down to the Zechstein. Afterwards, a stratigraphic correlation, depth adjustment and thickness correction of the different units were performed based on existing borehole data from the study area. Borehole and literature data were further used for model parameterisation.

Subsequently, the model was gridded in Petrel and transferred into the reservoir simulator TOUGH2-MP to perform large-scale numerical multi-phase multi-component (CO_2, NaCl, H2O) flow simulations. Furthermore, the gridded model was applied in the geomechanical simulator FLAC3D to identify changes in the recent stress field and deformation resulting from the pressure elevation during CO_2 injection [4-5]. In the present modelling study 1.7 Mt CO_2/year were injected into the top of an anticline structure of the 23 m thick sandstone formation of the Middle Bunter for 20 years of simulation time. A one-way coupling between both simulators was undertaken by transferring the pore pressure distribution from the dynamic flow simulations into the geomechanical simulator for selected time steps.

The results show that detailed knowledge on geomechanical processes during CO_2 injection is of uttermost importance for the assessment of fault reactivation and ground uplift and associated risks.

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