Geophysical Research Abstracts
Vol. 16, EGU2014-13799, 2014
EGU General Assembly 2014

On the possible fault activation induced by UGS in depleted reservoirs

Massimiliano Feronato (1), Giuseppe Gambolati (1), Carlo Janna (1), Pietro Teatini (1), and Omar Tosattto (2)
(1) University of Padova, Dept. of Civil, Environmental and Architectural Engineering, Padova, Italy, (2) M3E S.r.l., Padova, Italy

Underground gas storage (UGS) represents an increasingly used approach to cope with the growing energy demand and occurs in many countries worldwide. Gas is injected in previously depleted deep reservoirs during summer when consumption is limited and removed in cold season mainly for heating. As a major consequence the pore pressure p within a UGS reservoir fluctuates yearly between a maximum close to the value p_i prior to the field development and a minimum usually larger than the lowest pressure experienced by the reservoir at the end of its production life. The high frequency pressure fluctuations generally confine the pressure change volume to the reservoir volume without significantly involving the aquifers hydraulically connected to the hydrocarbon field (lateral and/or bottom waterdrive). The risk of UGS-induced seismicity is therefore restricted to those cases where existing faults cross or bound the reservoir. The possible risk of anthropogenic seismicity due to UGS operations is preliminary investigated by an advanced Finite Element (FE) - Interface Element (IE) 3-D elasto-plastic geomechanical model in a representative 1500 m deep reservoir bounded by a regional sealing fault and compartimentalized by an internal non-sealing thrust. Gas storage/production is ongoing with p ranging between p_i in October/November and $60\%p_i$ in April/May. The yearly pressure fluctuation is assumed to be on the order of 50 bar. The overall geomechanical response of the porous medium has been calibrated by reproducing the vertical and horizontal cyclic displacements measured above the reservoir by advanced persistent scatterer interferometry. The FE-IE model shows that the stress variations remain basically confined within the gas field and negligibly propagate within the caprock and the waterdrive. Based on the Mohr-Coulomb failure criterion, IEs allow for the prediction of the fault activated area A, located at the reservoir depth as expected, and slip displacement d. A number of parametric scenarios are investigated to address the major uncertainties on the geomechanical fault properties, i.e., cohesion c and friction angle ϕ of the fault materials, and the initial stress regime (passive or compressive basin). The magnitude M of potential seismic events induced by the fault reactivation is evaluated by an empirical relation derived from seismological theories. M turns out to be correlated to the activated volume $A \times d$ and the shear modulus G of the host rock. With $G = 3.9 \times 10^4$ bar, as provided by the calibration of the geomechanical model, the results point out that M may peak up to around 1 in the most conservative scenario, i.e. $c = 0$ bar, $\phi = 30°$, entirely instantaneous slip and a passive stress basin. With $c = 10$ bar, a plausible value for the investigated reservoir, the fault does not activate. Under the above conditions fault activation by UGS does not appear to be a matter of concern.