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Coupled HM modeling assists in designing CO2 long-term periodic injection experiment (CO2LPIE) in Mont Terri rock laboratory

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We are performing a series of coupled hydro-mechanical (HM) simulations to model CO_2 flow through Opalinus Clay at the Mont Terri rock laboratory in the CO_2 Long-term Periodic Injection Experiment (CO_2LPIE). CO_2LPIE aims at inter-disciplinary investigations of the caprock sealing capacity in geologic CO_2 storage in a highly monitored environment at the underground laboratory scale. Numerical modeling allows us to gain knowledge on the dynamic processes resulting from CO_2 periodic injection and to assist the experimental design. The cyclic injection parameters (i.e., the period and the amplitude) have to be optimized for the field experiment and therefore different values are taken into account. Opalinus Clay is a claystone with nanoDarcy permeability that contains well developed bedding planes responsible for its anisotropic HM behavior. The hydraulic anisotropy is defined by a permeability parallel to the bedding planes being three times the one perpendicular to it. Additionally, the drained Young's modulus is measured to be 1.7 GPa parallel and 2.1 GPa perpendicular to bedding. Excavation reports by swisstopo document a SSE-dip of 45° for the bedding planes at the experiment location. CO_2 injection generates a mean overpressure of 1 MPa into the brine that propagates into the formation. The differential pressure between CO_2 and formation water, i.e., capillary pressure, is lower than the entry pressure and thus, CO_2 diffuses through the pores but does not advect in free phase. The liquid overpressure distribution is distorted by the hydraulic anisotropy, preferentially advancing along the bedding planes, as the associated permeability is higher than the one perpendicular to the bedding. The pore pressure buildup induces a poromechanical stress increase and an expansion of the rock that leads to a permeability enhancement of up to two orders of magnitude. The cyclic stimulation propagates trough the domain faster and with a lag time and an attenuation, both of which increase with distance from the source with, their values being dependent on permeability, porosity and stiffness of the rock. As a result of the model orthotropy, the attenuation and the lag time change with direction, i.e. they are higher in the direction perpendicular to the bedding and lower in the direction parallel to the bedding. Given the very low permeability of Opalinus Clay, the

overpressure generated requires a long time to diffuse into the rock. Furthermore, the amplitude attenuation dissipates quite rapidly, so monitoring wells should be placed as close to the injection well as possible. The study of amplitude attenuation and time lag is necessary to determine how they can be utilized to evaluate the evolution of the HM properties as the rock is altered by the acidic nature of CO_2-brine mixture Comparison between field data and numerical simulations will be a useful asset to fill the gap.