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High Pressure Injection Test for Hydromechanical and Onset of Induced Microseismicity Characterization of CO_2 Injection Sites

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The large amounts of CO_2 that will be injected in deep saline aquifers as a supercritical fluid can dramatically increase fluid pressure around the injection zone. This reduces the effective stresses and increases shear stresses. Consequently, the rock undergoes deformations. These deformations can become large if the rock yields (Vilarrasa et al., 2010). Yielding is associated to microseismicity. Induced microseismicity is associated to fluid injection at depth and in particular to CO_2 injection (Verdon et al., 2011). The fluid pressure evolution and the deformation patterns are dependent on the hydraulic and mechanical properties of the reservoir and the caprock.

Hydraulic and mechanical properties can be determined from core samples in the laboratory. However, the resulting values are not representative at the field scale. Thus, field tests are needed for a proper characterization of potential CO_2 injection sites. The hydraulic properties can be determined from the interpretation of pumping tests. The transmissivity and the storage coefficient of the aquifer can be estimated using the Jacob method. The mechanical properties, i.e. the Young's modulus and the Poisson ratio, of the aquifer and caprock can be determined from the pressure and displacement measurements, but a standard method for estimating these properties from field measurements does not exist.

Pressure and deformation measurements when injecting water at high pressure can give valuable information on the hydromechanical parameters of the aquifer and caprock. A dimensional analysis of this hydromechanical problem gives three dimensionless numbers that govern the hydromechanical behaviour. Two dimensionless numbers depend on the mechanical properties of the rock. The other one depends on the geometry and can be set equal to one, reducing the number of dimensionless numbers to two. We plot the dimensionless pressure and vertical displacement as a function of the two dimensionless numbers. We can then estimate the values of the Young's modulus and the Poisson ratio of the aquifer and the caprock by introducing the field measurements in these plots. Fluid pressure and displacement evolution have to be measured both in the aquifer and the caprock, at the injection well and, if possible, at observation wells.

Furthermore, the capability of the caprock of supporting high injection pressures can be evaluated by progressively increasing the injection pressure and monitoring microseismicity. The maximum sustainable injection pressure coincides with the onset of microseismicity. The time evolution of microseismicity can give information on the permeability anisotropy, the stress regime and plastic strain propagation. However, it is recommendable to avoid large number of microseismicity events to keep the caprock integrity and prevent the formation of preferential paths towards the ground surface for future CO_2 injection.

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