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Experimental rig to improve the geophysical and geomechanical understanding of CO_2 reservoirs

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The capture of CO_2 from stationary sources and injection of CO_2 into deep geological formations through boreholes (Carbon Capture and Storage - CCS) is a possible technological, global scale solution to mitigate against rising levels of atmospheric greenhouse gases. Reservoir rock stability during injection is typically monitored with time-lapse (4D) seismic surveying tools, that could help to discriminate between fluid pressure and fluid saturation changes. To test and calibrate these seismic methods, we intend to perform experiments that simulate real CCS conditions in the laboratory, and hence provide the necessary knowledge to interpret field seismic surveys.

Primarily, the research is focused on determining seismic rock properties (i.e. wave velocities and attenuation) of real and artificial 50 mm diameter brine-CO_2-bearing sandstone and sand samples that are representative host rocks of real CCS scenarios. We plan to integrate into a new triaxial cell system both an ultrasonic pulse-echo method for accurate velocity ($\pm$ 0.3%) and attenuation ($\pm$ 0.1 dB/cm) measurements, and an electrical resistivity tomography (ERT) method to monitor homogeneity of pore fluid distribution within the samples. The use of ERT provides calibration data for field scale techniques (such as marine controlled source electromagnetic surveying) but also allows measurements of bulk resistivity, fluid diffusion monitoring, flow pathway characterization, and determination of the relative permeability for different brine/brine-CO_2 ratios. By simultaneously measuring ultrasonic P- and S-wave velocities and electrical resistivity, we also provide data for joint inversion of seismic and electric field data. Furthermore, the stress-strain behavior of the sample is continuously monitored with the aid of electrical gauges, so that we deal consistently and simultaneously with the geophysical and geomechanical response of the reservoir when submitted to CO_2 injections.

Typically, flooding tests with supercritical CO_2 in the laboratory are performed on experimental rigs specially designed for conducting flow through porous media at high pressure conditions. Far from trivial, the rig must be carefully designed to meet the requirements of each simulating scenario: the accurate control of pore fluid, confining pressure, temperature and flow, and integrated monitoring tools are essential. Thus, we present a helpful protocol regarding the design and assembly of high pressure experimental rigs to supercritical CO_2 injection tests.