Understanding potential caprock failure through fault zone leakage is crucial for the safe, long-term containment of a CO$_2$ storage site. Thus, the presence of faults in caprocks will greatly affect the site characterization process in terms of the safety assessment. The CS-D experiment at the Mont Terri Lab aims at investigating caprock integrity by determining CO$_2$-rich water mobility in a fault zone. Seven boreholes were drilled in the clay rock, all crosscutting a fault at depths of 17-30 m below the niche floor. The boreholes were fully cored, and the samples analysed in various laboratories. All boreholes were instrumented for monitoring geochemical and geomechanical changes induced by fluid injection for prolonged time, with the goal to better understand mechanisms of CO$_2$ leakage in a faulted caprock. We deployed a multi component monitoring setup measuring pressure, axial and 3D deformation, seismic activity and cross-hole electrical resistivity. A borehole was fully dedicated to the monitoring of the injection front, as well as geochemical in-situ measurements and fluid sampling. A portable mass spectrometer for direct measurements of gas has been installed in a dedicated borehole interval. Injection and monitoring activities started in December 2018, with multiple injection tests with saline water at pressures up to 6 MPa, in order to characterize the hydraulic response of the fault. A prolonged injection of CO$_2$-saturated water at constant head pressure started in June 2019 and lasted for about 8 months. In this contribution, we will present the analysis of the data collected during the fault characterization (hydraulic, geophysics, and core analysis) as well as results of the continuous months-long injection. Preliminary interpretation of the monitoring data suggests that a fault does not necessarily form a pathway for the fluid to escape at shallow depth.

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