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Joint elastic-electrical monitoring for detecting and quantifying CO_2-induced salt precipitation during geological carbon and storage

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Experimental rock physics allows the study of specific geological phenomena in a controlled manner. The experimental data are used to develop and calibrate predictive numerical models, which ultimately improve our understanding of natural processes and interpretation of field scale datasets. However, upscaling laboratory geophysical datasets to explain large scale geological complexes is challenging and by definition imprecise, as core-scale experiments are not fully representative of the events occurring in the field. This challenge gains in complexity with the increasing number of involved parameters and with changing environmental conditions. Nowadays, one of the most challenging rock physics areas is Carbon Capture Utilization and Storage (CCUS).

CCUS is a realistic global scale mitigation solution to tackle the excess of CO_2 expelled from industrial production and sequestering it into deep reservoir formations, while attempting at generate energetic benefits from this process (e.g., enhanced oil recovery and geothermal energy). When CO_2 is injected in rocks, the parental pore fluid is displaced by CO_2 and therefore the effective bulk modulus of the fluid (and the rock) changes; if the rock and/or the fluid are reactive to CO_2, then the rock frame and fluid composition are also changing parameters, affecting both the elastic and hydrodynamic properties of the original rock.

In this contribution, I examine the complexity of the geophysical interpretation of a specific CCUS-related process: CO_2-induced salt precipitation in saline aquifers. In essence, injected CO_2 dry out the brine and salt precipitates in the pores, leading to some degree of clogging that depends on, but not exclusively, the pore size, salt volume and pore connectivity. This phenomenon affects the injectivity of the CO_2 storage site, which could lead to pressure built-up events and ultimately compromise the geomechanical integrity of the reservoir. Therefore, an early warning of CO_2-induced salt precipitation is essential to apply specific mitigation strategies in a timely manner.

Salt precipitation is a rapid, self-enhanced process, with a footprint in the geophysical record that has to be isolated from that of the CO_2 fluid replacement and other potential CO_2-induced rock reactions. When the geophysical data include seismic and electromagnetic surveys, S-waves provide information about the changes in the rock frame, while P-waves and electrical resistivity would help to distinguish between CO_2, brine and salt fractions. Here, I use a dataset generated in

the laboratory using ultrasonic P- and S-waves attributes, resistivity and axial deformation, during a CO_2-brine flow-through experiment with salt precipitation, to discuss the potential of the rock physics to detect and quantify dynamic changes in the bulk properties of reservoir rocks.