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Laboratory testing for monitoring of reservoir properties during water injection

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Since the performances of geological reservoirs are continuously changing during the production history, tools capable of characterizing these changes are becoming day by day of relevant importance. A time-lapse monitoring is an important and widely used way to explore the variations induced by the oil depletion. In an enhanced oil recovery scenario, the seismic survey method has been mostly used to monitor the remaining oil fraction with respect to the injected water, however no particular attention has been addressed to the effects generated by the water-rock interaction, which might induce deformation with no stress variation. Indeed, it is well known that water can induce important mechanical weakening in reservoir rocks.

For that purpose, we performed injection tests on carbonate rocks in a conventional triaxial cell. An essential characteristic of these tests is the very low injection pressure, in order to minimize changes in the effective stresses and focus specifically on the rock - fluid interaction. The test consists in injecting water from the bottom in a critically loaded sample, initially in a dry state, until deformation is induced by the water-air substitution and failure is reached. While testing, the rock sample is instrumented with either 6 (at UCP, GEC lab) or 16 (at CSIRO, Geomechanics and Geophysics lab) P-wave transducers allowing us to perform an active ultrasonic survey with a narrow time intervals.

The described methodology allowed us to monitor how P-wave attributes (amplitude, velocity and frequency), elastic moduli, as well as, permeability and injection rate change while water is flooding the sample increasing the water saturation, and damage is produced by the water – rock interaction. For instance, injecting water into a dry rock sample could produce several patterns of variations in the P-wave velocity, which we ascribed to 1) partial water saturation; 2) water-induced damage with no failure; 3) water-induced failure and, in some cases, 4) total water saturation. More experiments are planned to mimic real EOR operation, like injecting water in an oil-saturated rock sample, with acoustic monitoring as well.

The outcome of this study indicates that combining multiple data sets from different sources is an effective tool for monitoring the exploitation of underground resources. This can certainly enhance our understanding of reservoir properties changing over time and target the attention

toward the areas of greatest interest.