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Impact of compaction, dissolution and precipitation on porosity and permeability dynamics of chalk

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Porous chalks are used as model systems for hydrocarbon reservoirs, and are used to understand how compaction and rock-fluid chemical reactions of dissolution and precipitation generate a complex porosity and permeability behaviour. Reservoirs experience years of water flooding. Hence, it is important to understand how this affects important petrophysical variables like porosity, permeability, pore size distribution, structural morphology and the affinity of minerals surfaces to reservoir fluids, with several years' period in mind. Here, we will report experimental results of a 1090 days chalk core experiment resulting in a complete chemical transformation by the flow of 0.219 M MgCl2 brine. The injected brine leads to dissolution of the chalk and precipitation of Mg bearing carbonates such as magnesite. The compaction and chemical reactions affect the overall porosity and permeability of the core. In addition, core permeability data from a series of 160 days core experiments with varying imposed stress (with and without compaction) display that not only porosity, but also specific surface area plays a role here. The specific surface area, i.e. the overall particle surface area in contact with a fluid, is correlated to the grain and pore size and is measured after the test is completed. In a third series of MgCl2 flow experiments, we inject tracers at intermediate steps to estimate the evolution in the surface area over time. The tracer test results are compared to specific surface areas of sections along the core after test. The sectional analysis reveals that the chemo-mechanical processes are non-uniform along the core. This is because the chemical composition of the fluid is changing through the core, and hence the rock fluid interactions will differ at entry, in the middle and as the fluid exits the core. We show how to combine the overall porosity and permeability measurements on core scale to the non-uniform chemical alterations along the axis of the core.