A complex Carbonate Characterization by Digital Rock Physics and NMR Methods during Centrifuge Desaturation

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Abstract. Digital core physics (DRP) has significantly advanced with the application of Deep Learning. One example is the drastic reduction of exposure time with similar image quality by using a convolutional neural network (CNN). It enables more DRP applications to the dynamic and quasi-dynamic displacement processes. Another advanced non-destructive technique, nuclear magnetic resonance and imaging (NMR or MRI), is an essential tool for petrophysical properties and displacement studies. This project aims to apply both DRP and NMR methods to monitor the saturation evolution of complex carbonate rocks during centrifuge desaturation.

Four core samples of different porosity, permeability, and micro/macro pore systems are selected. They are saturated with brine first and desaturated step by step in a centrifuge to an irreducible water state. The samples are initially scanned at two different qualities and scanned in shorter durations between centrifuge steps. NMR T2, saturation profile, and spatial T2 are also obtained at each step. The saturation profiles agree very well with both methods, while the T2 distributions indicate discrepancies for different types of rocks. High permeability samples with dominant macro pores agree better than low permeability samples with dominant micro pores. Both T2 spatial from NMR and microCT illustrate the effects of core scale heterogeneity. More comparisons on other pore scale modeling and simulation are planned.

The results indicate good agreement between the two methods on high permeability samples while the discrepancies of low permeability samples may be caused by the unresolved microporosity. Other methods are attempted to overcome the challenge. With its constantly improving efficiency and accuracy, it is expected that these non-destructive techniques would gain more application in daily operations compared to other destructive conventional methods.