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Mechanical effects of rock cement alteration quantified using digital rock physics

Maria Wetzel[1,2], Thomas Kempka[1,2], and Michael Kühn[1,2]
[1]GFZ German Research Centre for Geosciences, Section 3.4 - Fluid Systems Modelling, Potsdam, Germany
[2]University of Potsdam, Institute of Geosciences, Potsdam, Germany

Mineral dissolution is a micro-scale process, which may significantly alter the microstructure of rocks, and consequently affect their effective mechanical behavior at the macro scale. Predicting changes in rock stiffness is of paramount importance within the context of risk assessment for most applications related to geological subsurface utilization, where reduction of mechanical parameters is of particular relevance to assess reservoir, caprock and fault integrity [1].

In the present study, the effective elastic properties of typical reservoir rocks are determined based on micro-computer tomography (micro-CT) scans. The resulting three-dimensional rock geometry comprises a more realistic microstructure regarding the shapes of grains, cements and the overall porous network compared to available empirical approaches. Effective rock stiffness is calculated by a static finite element method, which imposes an uniform strain on the digital rock sample and calculates the resulting stresses. The effect of spatial cement distribution within the pore network is taken into account, considering passive pore filling as well as framework supporting cements. Rock stiffness increases due to the precipitation of pore-filling minerals. This quantitative approach substantially improves the accuracy in predicting elastic rock properties compared to general analytical methods, and further enables quantification of uncertainties related to spatial variations in mineral distribution.

[1] Wetzel M., Kempka T., Kühn M. (2018): Quantifying Rock Weakening Due to Decreasing Calcite Mineral Content by Numerical Simulations. Materials, 11, 4, 542. DOI: http://doi.org/10.3390/ma11040542