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Sensitivity study of an image processing workflow on synchrotron μ-CT images of Berea sandstone

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For the present study, the sensitivity of the threshold value for watershed-based segmentation and global threshold segmentation was assessed on μ-CT images of fine grained Berea sandstone. The sensitivities were assessed in terms of porosity, permeability, single-phase flow simulations and capillary pressure curves that were calculated from the segmented data. The μ-CT images of fine grained Berea sandstone with a resolution of 3 μm/pixel was segmented using different threshold values that were systematically varied, which resulted in slightly different structures for the pore space. The results show, that watershed-based segmentation is more robust than global threshold segmentation and that the measured permeability showed a stronger sensitivity to threshold variation than porosity, indicating that it is a more sensitive parameter to image segmentation settings.

Calculated permeability and capillary pressure curves matched well with experimental data revealing that the average pores and pore throats of the watershed-based segmented structure were segmented accurately. In contrast, capillary pressure curves indicated that pore sizes near the resolution limit of 3 μm, located in kaolinite rich areas of the rock, were not segmented correctly and thus caused the disagreement between the experimental measured porosity and that measured from the digital rock image. We conclude that capillary pressure curves and permeability values that result from the digital rock data is more indicative of the flow relevant fraction of the pore structure and are therefore better suited as validation criterion than porosity data.

Numerical modeling of two-phase flow on segmented data from high resolution μ-CT images enhances our understanding of the dynamics of multiphase-flow of immiscible fluids at the pore-scale. To be confident about simulated data it is therefore important to identify meaningful properties, e.g. permeability, that can be used as benchmark parameters for testing the quality of segmented data.