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A multiscale segmentation strategy for low-resolution, whole-core computerized tomography images of carbonates

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Image segmentation is a critical step in any digital rock workflow. The classification of voxels into phases representing grains, pores, and sub-resolution features affects all the subsequent quantitative analyses performed from the tomograms as well as numerical modeling of physical processes within pore and solid phases. Although it has been an active research field for many years, segmenting 3D porous media remains a non-trivial problem; different rock types and image resolutions require different approaches; it becomes a formidable problem for the analysis of images containing multiscale features. An important practical example is the quantitative analysis of carbonate rocks, for which a single image resolution is often inadequate.

We develop a segmentation strategy targeting millimeter-scale resolution of computed tomography (CT) images of spatially complex carbonate rocks. The segmentation workflow has been designed with three objectives in mind: (1) reduction of biases imposed by the human operator, (2) automation of the process for a large number of samples, and (3) use of free available algorithm implementations for immediate reproducibility. It successfully identifies both relatively larger features such as vugs and inclusions as well as (unresolved) microporosity regions. CT image filtering using deconvolution, radial intensity correction, and histogram equalization at different stages of the analysis are found necessary for the success of segmentation method based on statistical region merging. Our workflow reduces the number of subjective input parameters and the corresponding results are in good agreement with borehole measurements of nuclear magnetic resonance and ultrasonic borehole image. A synthetic vuggy-porosity log along the images resulting from this workflow significantly improves the interpretation of in-situ nuclear magnetic resonance measurements across vuggy regions.

References

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