COMPUTED TOMOGRAPHY PARAMETERS FOR DIGITAL ROCK PHYSICS MODELS

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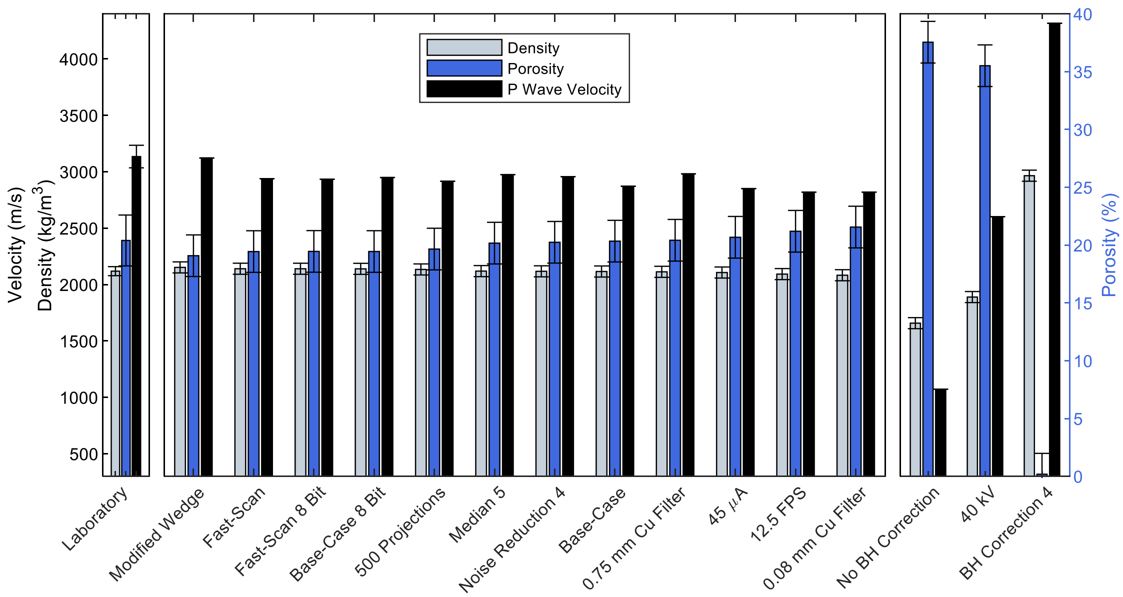
ABSTRACT

Digital rock physics (DRP) is the process of estimating physical properties of rocks from numerical models. In this paper, our models are acquired from Computed Tomography (CT), and we process them by calibrating our scans to density units using objects of known density included in the scan. The method is reliable if X-ray attenuation, approximated in units of CT number, can be reliably mapped to density. To test the sensitivity of our segmentation-less method, we conducted 32 scans with different setup conditions of 4 Berea Sandstone samples. We also varied post-acquisition processing, including applying different beam hardening corrections, and various noise filters. We observe that if acquisition voltage is above a minimum threshold, and beam hardening is addressed, density can be accurately determined (DRP uncertainty falls within laboratory uncertainty). Beam hardening can be addressed using numerical corrections, a modified-wedge, or physical beam filters – although a modified-wedge is a bulkier option, and beam filters may still require numerical correction. We observed that when the numerical beam hardening correction was properly selected, the R^2 of the CT-number to density calibration curve was 0.9999 and density estimates were accurate. Conversely, when the R^2 values was 0.9917 or lower, the results were inaccurate. Scans that cannot be used for accurate property estimations can be easily identified using this metric. Most other settings including X-ray source current, numerical noise filtering, exposure time, number of projections, and numerical bit size seem to have a little effect on the final density estimation (within 1.7% of base-case). Accurate density models can be converted to accurate porosity models - i.e., their uncertainty falls within laboratory uncertainty; while DRP results for P-wave velocity fall within 8.4% of laboratory measurements. Inaccurate density models do not carry through accurately to other rock properties. We show that a scan with few projections, a fast exposure time, and half the bit depth still yields accurate results, despite a 3 minute acquisition time and half the dataset size.



Estimates of porosity and P wave speed for sample 1 with under selected circumstances. Density and velocity are plotted on the left axis, and porosity is plotted on the right axis. Left panel: physical laboratory measurements. Middle panel: accurate DRP results. Right panel: inaccurate DRP results. Data values are included in Supplementary Materials.

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