CALCULATING EFFECTIVE ELASTIC PROPERTIES OF BEREA SANDSTONE USING SEGMENTATION-LESS METHOD WITHOUT TARGET

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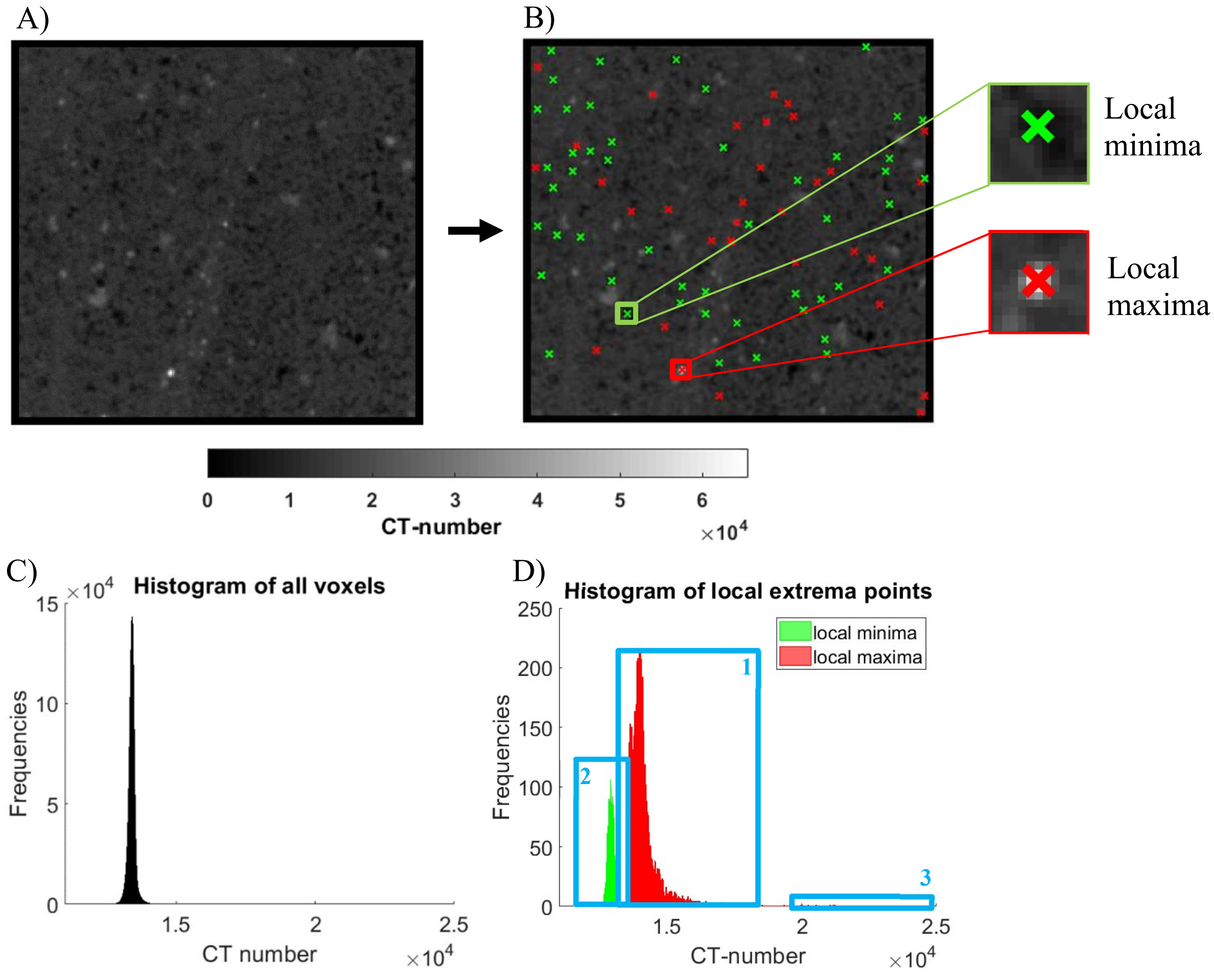
ABSTRACT

We are proposing a new method to compute elastic properties of rocks from computerized tomography images (CT-images). The procedure improves an already existing segmentation-less approach where CT-images are automatically converted to elastic property arrays without passing through segmentation. One drawback of the classic segmentation-less approach is that it typically requires phantoms, or targets of known density to be scanned along with the sample. These targets are used to map CT-images into petrophysical property arrays by comparing the X-ray attenuation of the phantoms to the sample. We introduce a segmentation-less workflow that no longer requires physical targets. Instead, this technique defines pseudotargets, within the sample itself by capturing local extrema points in the CT-images. Then, we assume those points to be centers of specific mineral grains and pores. The average of X-ray attenuation for such maxima and minima are then defined as references (i.e., pseudotargets). We have benchmarked this technique against a segmentation-less approach that used targets, as well as the more popular segmentation approach. In all three cases, we evaluate elastic wave-speeds on Berea sandstone samples. In our study, three pseudotargets have been defined: quartz, pyrite, and air. Our approach, the segmentation-less without targets, yields the least velocity error. This is +1.2% for P-waves, whereas segmentation and segmentation-less compared are +41% and +2.0% to laboratory measurements. Next, we conduct a sensitivity analysis for the proposed method. A systematic investigation shows that a variation of 1.1% in the X-ray attenuation reference for the quartz phantom yields an error of 9.2% on P-wave velocities. To avoid such uncertainty, we use an inversion technique to adjust the parameters. Here, we invert for the X-ray attenuation value of each phantom by minimizing the mismatch between the sample porosity which is measured in the laboratory and that computed from the CT-images. The wave-speed error after the inversion process decreases to a negligible amount (less than 1%) for P-wave and 12% for S-wave. The robustness of the algorithm has been cross-validated on a second Berea sandstone core. Therefore, the segmentation-less without targets with fine-tuning via inversion allows effective elastic properties to be solved with insignificant error. The proposed method could serve as a supplementary and reliable technique for estimating elastic properties of monomineralic rocks from CT-images.



A result of running the searching algorithm with ϵ=8 on the UT01 sample. The left figure (A) shows a slice of the CT-cube. The right figure (B) shows the location of the local extrema (red) and local minima (green) points. Both images are colored based on their CT-number. The bright color represents high CT-number (i.e., high-density material), and vice versa. The field of view is 8.0 mm x 8.0 mm. The algorithm marks local extrema points where we assume them to be the center of mineral grains and pores. Figure C and D shows the corresponded histogram for A and B, respectively. Note that the histogram D represents only for the local extrema points. The histogram D consists of 3 zones, each of which is the local extrema CT-number corresponding to quartz (zone 1), air (zone 2), and pyrite (zone 3).