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Dynamic elastic properties from micro-CT images: modeling and experimental validation

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Knowledge of the elastic properties of rocks is a key factor in seismic interpretation. Elastic properties of rock are determined by its microstructure and their prediction relies on the availability of accurate microstructural models. X-ray computer tomography (CT) as a unique non-destructive technique is becoming a powerful tool in geophysics research which reveals detailed 3D microstructure of rock with special resolution of 1 micron. Recent breakthrough in computational capabilities allows simulation of elastic properties directly using the micro-CT images. In this study we simulate acoustic velocities of sandstones, based on high resolution 3D images and compare simulation results with ultrasonic measurements. Synchrotron images of two sandstones are segmented to separate grain from pore space. The porosity obtained as a result of the segmentation process is compared with the measured porosity for the segmentation quality control. Parallel 3D finite difference (FD) code is used to simulate elastic wave propagation through the digitized two phase media where the total solid phase is supposed to have elastic properties of intact quartz and the pore space is either dry or saturated with water. Attenuation and dispersion of acoustic velocities are obtained at a range of frequencies. The numerical results noticeably overestimate velocities obtained at laboratory experiments at ultrasonic frequencies. The discrepancy can be explained with the fact that grain contacts have strong effect on elastic moduli and are the most speculative part of the simulations. To validate our FD code and calibrate the properties of grain contacts, we simulated elastic wave propagation in aluminum foam with porosity of 40%. All grain contacts in the foam are "solid" and its microstructure is similar to that of moldic carbonates. Preliminary results of FD modeling and comparison with experiment of carbonates are presented as well.