Contribution ID: **251** Type: **Pre-Recorded Oral Presentation 3**

How to take into account of clay content in computing elastic moduli of arenites from micro-tomographic images

Derivation of rock physics models for elastic moduli estimation often relies on either simplified models of rock microstructure or empirical relationships established for a particular laboratory data set. Ideally, one would need to calibrate the abstract model parameters to available petrophysical and petrographical (micro-CT images, thin sections, etc.) data. However, elastic properties obtained by numerical simulations for micro-CT images of rock microstructure are considerably higher than those inferred from laboratory measured ultrasonic velocities. Imperfect image segmentation algorithms and image resolution may contribute to this systematic bias. Here, we propose a digital rock physics workflow that provides a robust calibration for velocity-porosity relationships in sandstones with dispersed clay. To this end, we analyse a set of images of Bentheimer sandstone samples accompanied by stress-depended ultrasonic measurements. The results are also compared with the measurements on sandstones by Han et al. (1986).

Quartz is the main constituent of Bentheimer sandstone, with small fraction of feldspar and clay minerals (mainly kaolinite). Bulk and shear modulus of quartz are relatively well defined: bulk modulus K = 37GPa and shear modulus G = 44GPa. Experimental measurements of kaolinite moduli are challenging, with the most convincing experiment (Vanorio et al., 2003) reporting bulk modulus K = 12GPa and shear modulus G = 6GPa. With such contrast, it is important to accurately map clay minerals in the solid material.
Standard segmentation algorithms provide no robust solution to this problem. X-ray absorption for clay particles is similar to that for quartz, they cannot be distinguished by a simple threshold. Here, we propose a new segmentation workflow that relies on both pixel intensity and morphology of clay particles. The main steps are:
• Median filter suppresses random noise and blurs the images;
• Intensity of the clay regions decreases due to presence of micro pores;
• Three-phase Otsu algorithm segments clay together with grain boundary artefacts as a separate phase;
• To remove the grain boundaries from the clay phase, we apply the opening algorithm, which is a sequential erosion and dilation operations, that eventually removes the thin shell-like artefacts;
• Finally, the clay region is used as a mask for the binary segmented image.

This workflow results in a reasonably accurate distribution of mineral phases.

Then, with the moduli computed for scans with different resolution we fit a linear relationship to extrapolate our estimates to the infinite resolution. Our calculation clearly shows that imperfect image segmentation algorithms and image resolution may be considered as the main reasons for the systematic bias between computed and measured moduli. Through the above adjustment, our digital rock physics workflow not only provides a robust calibration for modulus-porosity relationship, but also the modulus-clay relationship for sandstone with dispersed clay.

Acceptance of Terms and Conditions

Click here to agree

References

Han, D.-h., Nur, A. and Morgan, D. [1986] Effects of porosity and clay content on wave velocities in sandstones. Geophysics 51(11), 2093-2107.

Vanorio, T., Prasad, M. and Nur, A. [2003] Elastic properties of dry clay mineral aggregates, suspensions and sandstones. Geophysical Journal International 155(1), 319-326.

Authors: LIANG, Jiabin (Curtin University); Dr GLUBOKOVSKIKH, Stanislav (Curtin University); GUREVICH, Boris (Curtin University, Australia); LEBEDEV, Maxim (Curtin University); VIALLE, Stephanie (Curtin University); YURIKOV, Alexey (Curtin University)

Presenter: LIANG, Jiabin (Curtin University)

Track Classification: (MS21) Effective elastic, thermal, electrical and optical properties of porous materials, cellular materials, foams and metamaterials