Submission code: J8Q7QWAJ8B

See this and other abstracts on our website: https://home.sbgf.org.br/Pages/resumos.php

A multiscale pore inclusion modeling of pre-salt carbonates based on μCT image analysis and petrophysics measurements

Irineu Lima Neto (FACC/UENF), Roseane Misságia (UENF), Marco Ceia (UENF), Herson Rocha (UFRJ/FACC/UENF), Lucas Cesar Oliveira (UENF/FACC)

A multiscale pore inclusion modeling of pre-salt carbonates based on µCT image analysis and petrophysics measurements

Introduction and data set

This work employs complex pre-salt carbonates (Barra Velha Fm. at Santos Basin, Brazil) to address a multiscale pore inclusion approach based on three µCT resolutions, petrophysical and ultrasonic P-S-wave velocity (Vp and Vs) measurements. The goals include characterizing the pore system by µCT data for three direct inclusion scales, analyzing the minimum and maximum pores facing image limitations to predict micropores (fourth inclusion), under the best resolution (voxel resolution of 1.27 µm at 5X), calibrating a rock physics inclusion model to determine pore aspect ratio based on Vp, and thereafter predicting Vs.

The data set comprises 5 plug-samples cored from a high-energy environment as predominantly bivalve grainstones and arborescent shrubs. Laboratory measurements evaluate mineralogy, porosity, and ultrasonic Vp, Vs using a triaxial system under confining pressure (5.5-22.1 MPa) and dry sample conditions. The XRD analysis and Rietveld method quantify mineralogy and compute the mineral elastic moduli and density. The porosity and permeability are estimated by helium/nitrogen gas slip by Coreval 700. Three different resolutions of µCT data were employed for analysis: 1) specimens at plug scale (~38 mm in diameter) were imaged by a Bruker SkyScan 1173, an X-ray cone bean source, reaching a voxel resolution of 12.14 µm; different specimens of 2) ~6 mm and 3) ~2.5 mm in diameter, which were made using a reserved piece taken from plug-samples, resulting in voxel resolution of 3.33 µm (2x) and 1.27 µm (5x), respectively, both acquired using a high brightness synchrotron light source at MOGNO beamline facilities (SIRIUS/LNLS/CNPEM).

Method and Theory

All three scales of available µCT data volumes were reconstructed and segmented by the steps: 1) 8-bit grayscale volumes are evaluated avoiding noise areas, correcting brightness & contrast, and using filters as necessary (e.g., ring artifact removal); 2) image segmentation performing single thresholding by Otsu algorithm and guided by an interpreter, identifying the mineral matrix and pores; 3) pore segmentation isolating pores by ellipsoid fits, aiming to compute geometry properties (area, perimeter, aspect ratio, etc.). A multiscale pore inclusion Rock Physics method is proposed, adapting the dual pore inclusion approach from Lima Neto et al. (2014). The pore inclusions are established from µCT scales, and micropores under the best resolution to determine the aspect ratio are iteratively computed from Vp at minimum error between predicted and measurement. Thus, the DEM (Differential Effective Medium) model estimates the bulk and shear moduli by the supposed pore aspect ratio inclusions, and the Vp is iteratively computed for comparison with laboratory measurements. After that, the calibrated elastic moduli are applied to predict Vs and evaluate error by comparison with laboratory measurements. Pressure effects are evaluated by supposing porosity reduction in the modeling.

Results and Conclusions

Crossplots were developed for results from µCT analysis, especially for visible inclusion pores and aspect ratios. The multiscale inclusion modeling showed good fits as observed between the measured and predicted Vp for the five confining pressure values (5.1 to 22.1 MPa), as expected for a minimum error in methodology. The calibrated shear modulus from the invisible micropore aspect ratio using Vp was employed to compute Vs and compared with measurements, resulting in a reasonable fit (R=0.905), easily improved by the observed difference of ~200 m/s (R≈0.97), demonstrating high potential for complex carbonates.